# Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

APRIL 1961



four-high reversing mill and vertical edging mill
. . . for SLABS and PLATES

designed and built by MESTA

Designers and Builders of Complete Steel Plants
MESTA MACHINE COMPANY
PITTSBURGH, PENNSYLVANIA



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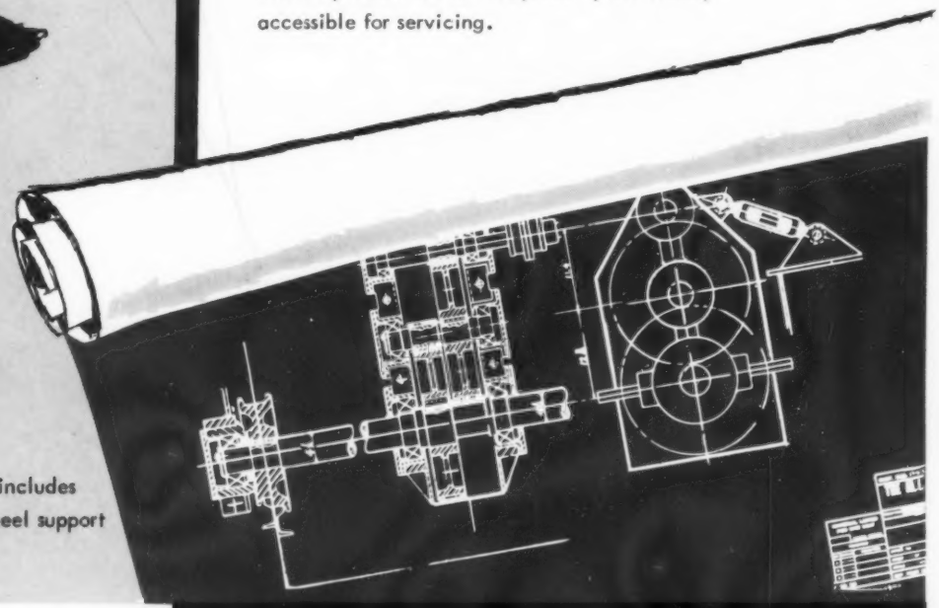

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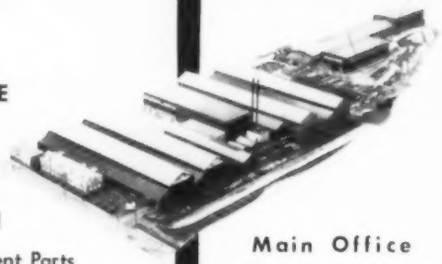

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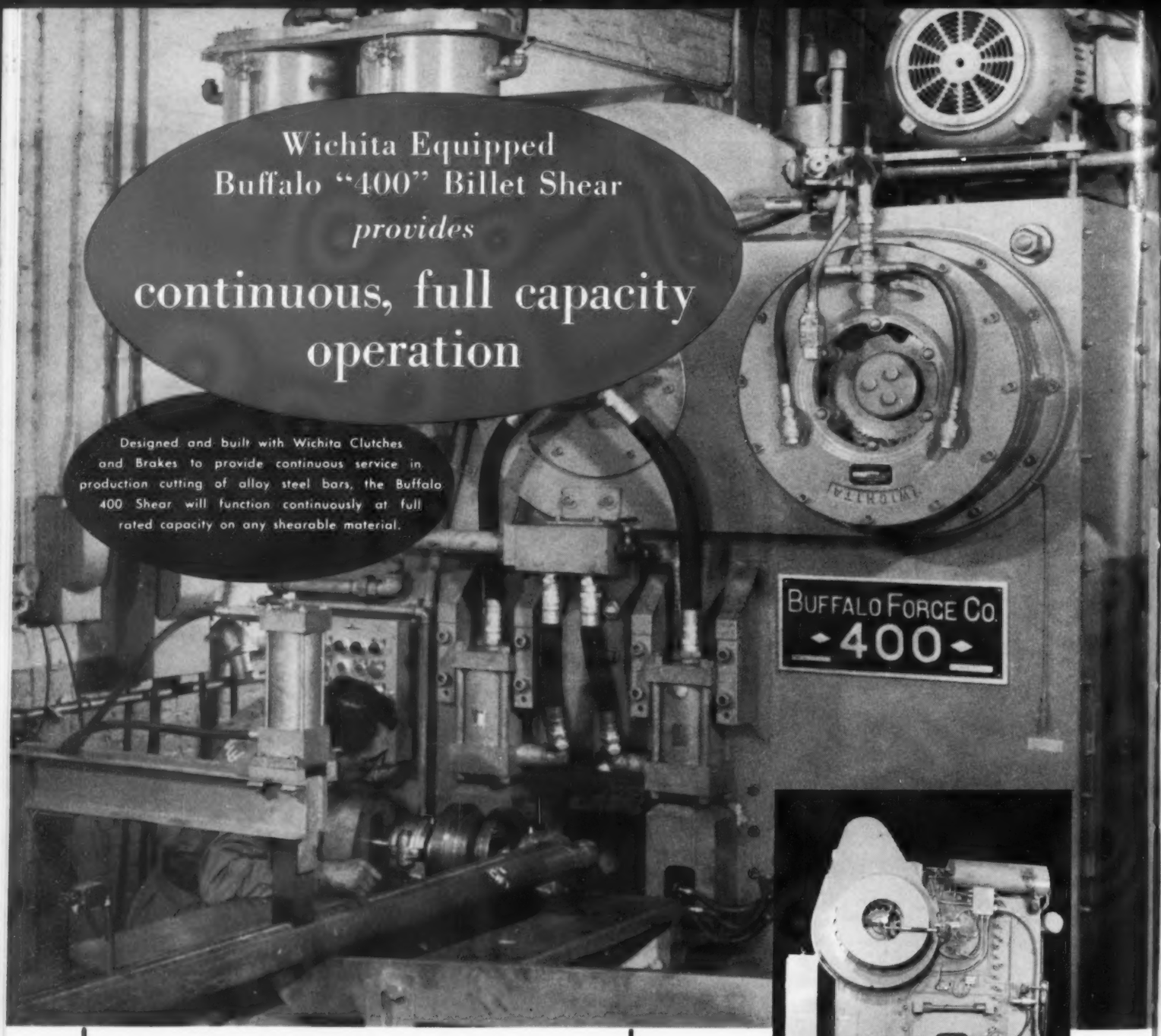


# Wichita Equipped Buffalo "400" Billet Shear *provides* continuous, full capacity operation

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*Says Buffalo Chief Engineer:*

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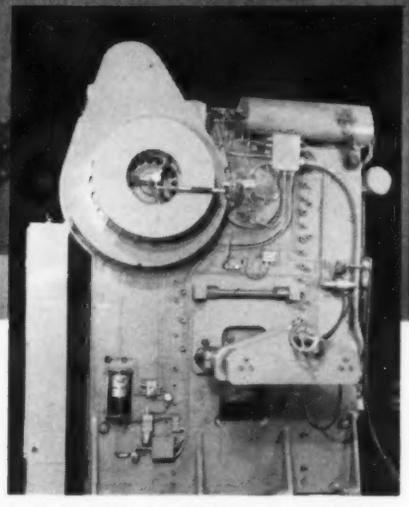

"Wichita Brake in main illustration and Wichita Clutch shown in inset above allow air to flow directly over the friction surfaces," says Buffalo Engineer, "and the air tube is located away from the concentrated heat zone. This spells high speed operation and satisfactory friction lining life."

Wichita Clutches and Brakes provide outstanding trouble-free service for all types of metalworking machines. For tough clutch and brake problems of any kind, call in a Wichita Engineer today!

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VOLUME XXXVIII • NUMBER IV APRIL, 1961

67 Oxygen Steelmaking in the Ajax Furnace of the Appleby-Frodingham Steel Co.
*by Albert Jackson*
76 Available Translations
77 Stretch-Reducing Operations at Colorado Fuel and Iron's Seamless Tube Mill
*by C. C. Crawford*
85 Selecting Electrical Drives for Applications Under 500 HP
*by F. A. Woodbury*
92 European Experience with the Electrically Heated Soaking Pit
*by H. C. Bjerke*
G-1 Granite City Steel Co.
*by T. J. Ess*
99 An Analysis of the Stresses and Deformations in Work Rolls
*by Carl F. Zorowski and Alvin S. Weinstein*
106 AISE Spring Conference Program
108 Abstracts of Technical Papers to be Presented at AISE Spring Conference Program
115 Analysis of Today's Tube Welding Processes
*by Norbert C. Rubin*
120 Current AISE District Section Meeting Notices
121 Reduction of Maintenance Through Modern Lubricants
*by J. R. Wicoff*
123 Orcarb Electric Furnace Process for the Direct Reduction of Iron Ore
*by W. R. Braddock*
126 What's New at DOFASCO
*by D. O. Davis*
133 Republic Steel Corp.'s 13-Ft Wire Mesh Facilities at Gadsden
*by C. J. Kinsey*
138 Digital Computers for Accounting and Control of Continuous Processing Lines
*by R. W. Kirkland*
146 Pictorial Roundup—AISE Western Meeting
148 A New Horizon in Management Planning
*by H. C. McClellan*
152 The Story of Atlantic City
*by W. F. Pruden*
157 Bethlehem's Steelton Plant Undergoes Further Diversification
161 Japanese Steel Capacity to Double by 1970
163 Dust Suppression Improves Operation and Industrial Relations

**DEPARTMENTS**

11 Crops and Shorts
25 Patent Reviews
65 Steel Angles
173 Date-line Diary
183 Industry News
201 Publication Service
207 Personnel News
221 Equipment News
239 Book Reviews
245 Index to Advertisers

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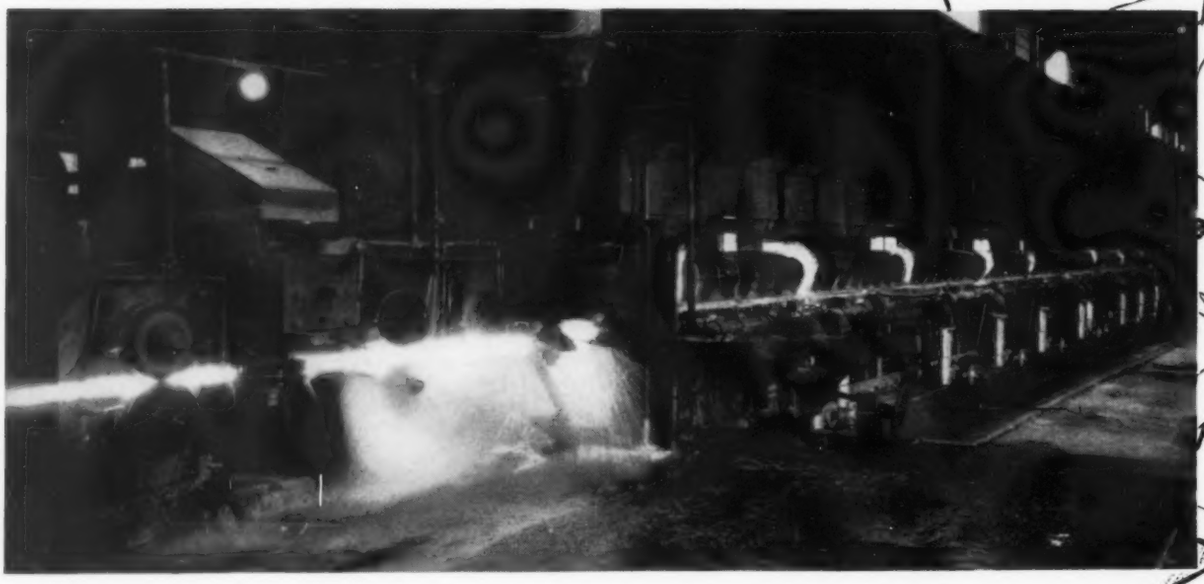
# TAMUL BRICK AND BURNER BLOCKS

## *speed production in continuous pipe mill furnaces*



**TAMUL**® (Taylor sintered synthetic mullite) refractories are preferred by operators of continuous butt-weld pipe mill furnaces . Heating cold skelp for ½" diameter pipe to 2500° F. in 21 seconds produces furnace conditions in which ordinary refractories quickly fail.

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The rotary billet shear (shown
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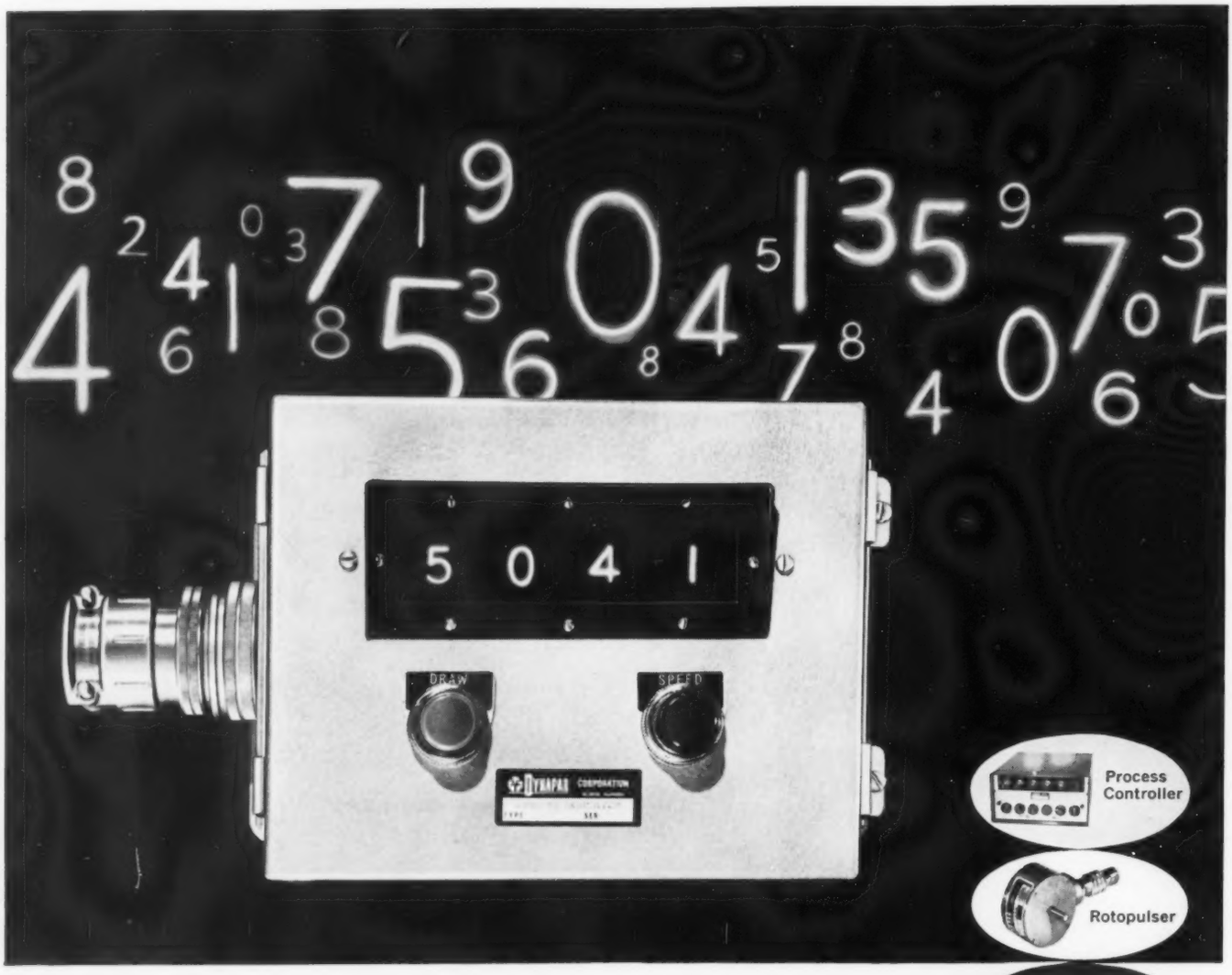


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Extensive research and wide experience enable Firth Brown to supply forged steel work rolls of the highest quality for cold rolling ferrous and non-ferrous sheet and strip. Rolls ranging up to 36 inches diameter and 23 tons are in regular production.

Forged steel back-up rolls are also a Firth Brown speciality; they can be supplied either as one-piece forgings or as sleeved rolls up to a diameter of 60 inches and weights of 56 tons.

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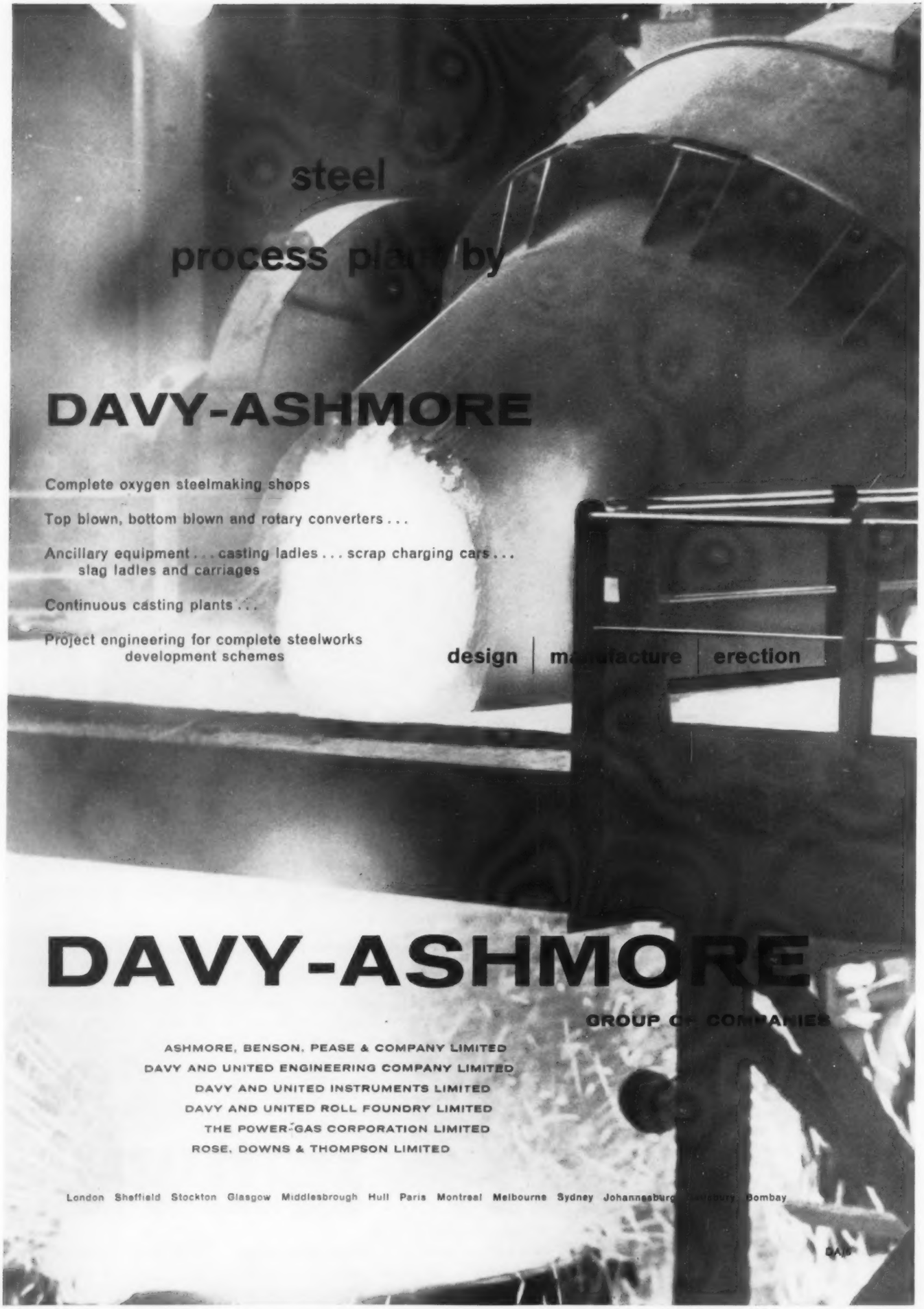
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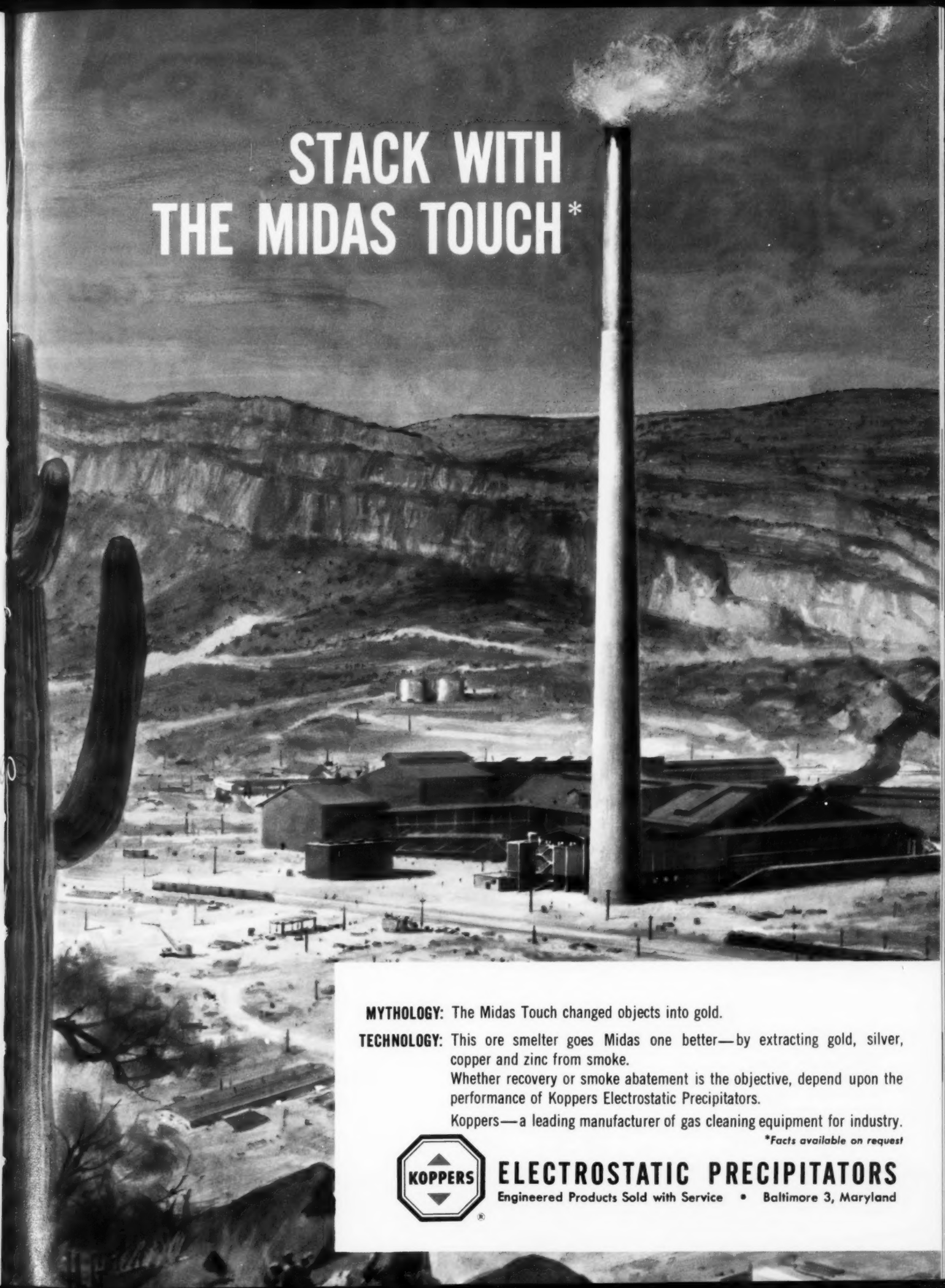


**MYTHOLOGY:** The Midas Touch changed objects into gold.

**TECHNOLOGY:** This ore smelter goes Midas one better—by extracting gold, silver, copper and zinc from smoke.

Whether recovery or smoke abatement is the objective, depend upon the performance of Koppers Electrostatic Precipitators.

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# Crops *and* Shorts

△ Unemployment figures are, to say the least, confusing. Reports indicate we have both record employment and record unemployment simultaneously. This is quite possible with the growth of our economy. But one thought persists. How many individuals hold two jobs? If this moonlighting were abolished, what would our unemployment be? Working wives further complicate the picture. A pregnant woman leaves her job to have the baby and, if she draws unemployment benefits, becomes an unemployment statistic. And of course there are always the several million who are basically unemployable. Maybe we're not as badly off as it sounds.

△ Other economic indicators can be equally confusing. Gross national product for 1960 is estimated at a record $503,200,000,000. Personal income was $404,200,000,000, a gain of 5.5 per cent over 1959. Retail trade reached a record of $219,800,000,000. Total employment set a record at 66,700,000. All this in a recession year.

△ The largest passenger-carrier? Almost any race horse. It can take thousands of people for a ride at the same time.

△ T. F. Patton, president of Republic Steel Corp., told stockholders that the general business decline is abating and that steel production should rise faster than the over-all economy. He said that Republic's new marketing program calls for intensive concentration in several important markets where rapid growth is assured and steel is not now the major fabricating material.

△ From a vacationing motorist:

My driving is perfection.
My courtesy is tops.
I've just caught the reflection
Of motorcycle cops.

△ As of February 24, satellites in orbit were as follows: Earth orbit: U.S.A. 20, U.S.S.R. 3; Solar orbit: U.S.A. 2, U.S.S.R. 2. Of these 11 U.S.A. satellites are transmitting, one U.S.S.R.

△ A Kansas state health officer lists three safe ways for men over 40 to safely shovel snow: "Get a power shovel. Hire the young boy next door. Let your wife do it."

We presume the same goes for mowing the lawn.

△ The effect of rising labor rates is sharply emphasized by the fact that labor costs now represent about 38 per cent of the industrial sales dollar, as compared to 25 per cent in 1950. In the steel industry, the figure was 39.5 per cent in 1960 and 30.9 per cent in 1950.

△ From comments of mothers of small children, there's a fortune waiting for someone who develops a cereal to reduce energy—sort of a corny tranquilizer.

△ New construction expenditures are expected to reach $57,300,000,000 in 1961, according to a forecast by the Business and Defense Services Administration of the U. S. Department of Commerce. This is 4 per cent above 1960 and about 2 per cent above the record year of 1959.

△ The Wall Street Journal says civilization can be measured by the degree of helplessness we feel when the electricity goes off.

△ The Value Line Investment Survey thinks the business recession has been halted, temporarily, at least, and a recovery will in all probability develop —how vigorously is open to question.

△ Maybe the reason you can't find a comfortable antique chair is that the comfortable chairs get worn out before they become antiques.

△ According to the American Society for Industrial Security, poor security practices are costing American companies hundreds of millions of dollars annually in losses through pilferage, in the employment of undesirables predestined to failure on the job, in the loss of company secrets and know-how, etc.

△ An experienced observer says that, while the dollar may not go as far as it used to, what it lacks in distance it makes up in speed.

△ The head of a large engineering organization commented recently to the effect that the steel industry did not push their product as strongly as some producers push their competitive materials. He said that salesmen for concrete, for example, call him frequently to urge the use of their product in new jobs. Steel, he says, seems to wait until it has been decided to use steel before coming into the picture.

Recent activities seem to indicate that the steel industry is at last aware of this and is starting more aggressive promotion. In view of the inroads made by competitive materials, it is no time for complacency.

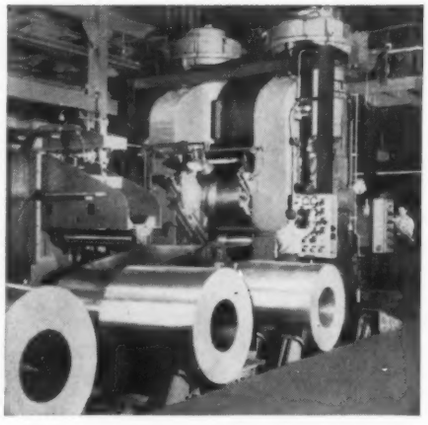
# Bliss mills add hardness to Weirton Steel's line of strip

Weirton Steel Co., Division of National Steel Corp., the nation's largest independent producer of tin plate, uses a Bliss mill to achieve exacting temper and quality of its strip prior to plating. It is a four-high, two-high two stand tandem mill recently installed in its Weirton, W. Va., plant.

Through this unit Weirton has rolled a wide variety of steels in gages ranging from .00435 to .0147 inches and at an average maximum speed of 4,500 feet per minute. Well known products such as Weircote and Weirzin zinc coated steel are just two of Weirton's steel products to which this mill contributes.

A second Bliss mill tempers high-carbon, high-phosphorous, deep-drawing and galvanizing steels at the rate of 800 tons a day, while a new Bliss 48-inch slitting line is used to slit galvanized steel in gages from .0135 to .135 inches at speeds of 200 to 1,000 fpm. Both rolling mills are equipped with Amerigear-Bliss spindles.

These three installations provide one more example of the ready acceptance of the name of Bliss in the rolling mill industry—both here and abroad. To learn how Bliss equipment can help increase your rolling capacity, simply write for our new 84-page Rolling Mill Brochure, Catalog 40-B.



Four-high temper mill handles 30,000-lb. coils at speeds up to 3,500 fpm...has rolled 1,000 tons in a single day. Back-up rolls were supplied by Bliss' Mackintosh-Hemphill Division.

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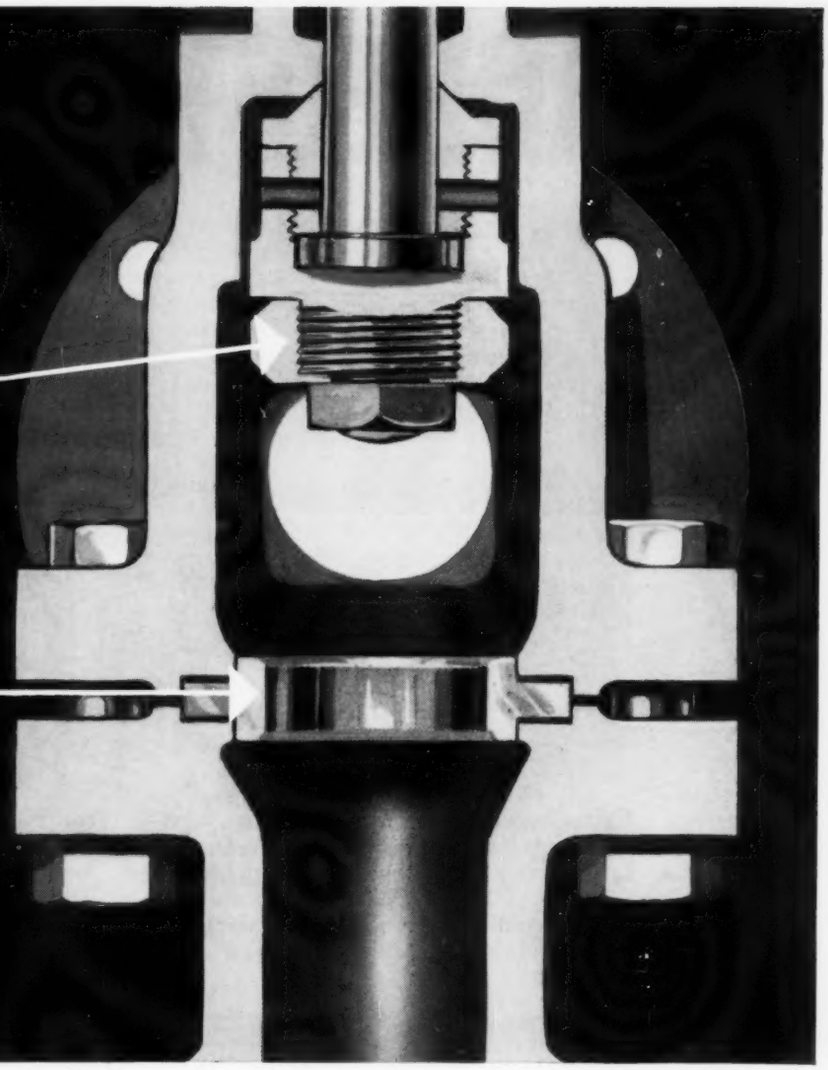
**Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio**

# EXTRA SEAT *and* DISC FREE



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City..... Zone..... State.....

160

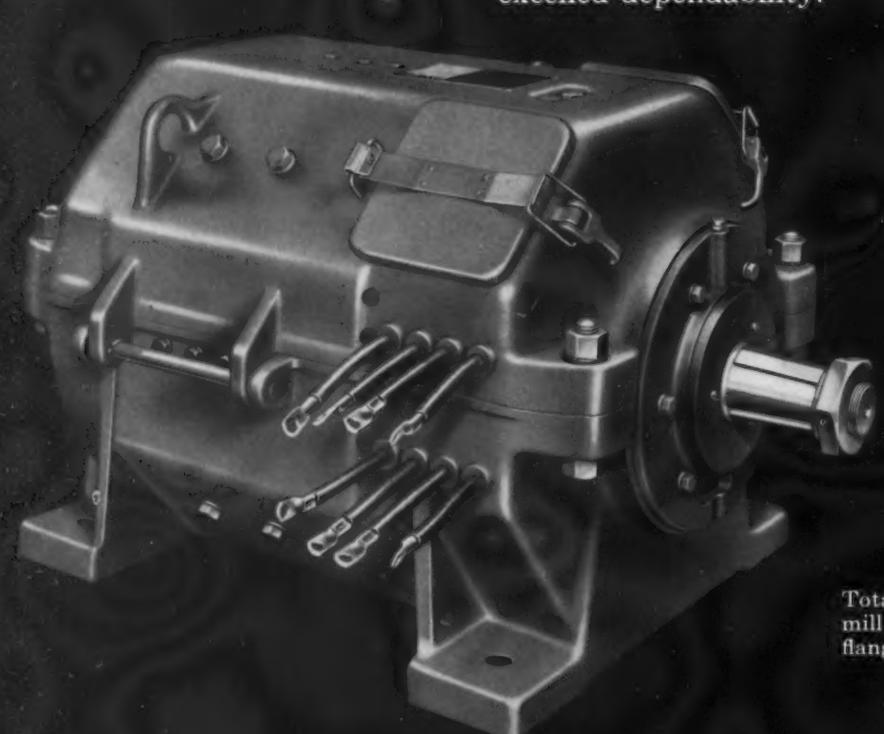
# ADVANCED ENGINEERING

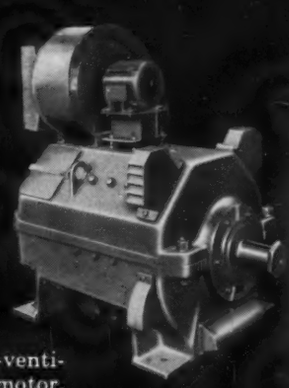
# ELLIOTT

# MILL MOTORS

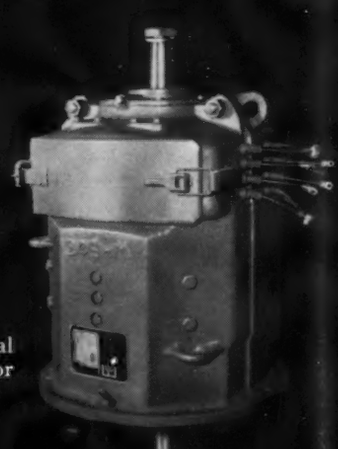
Extra reserve power, fast response, high efficiency, great mechanical strength, time-saving accessibility—these characteristics of Elliott Mill Motors are the result of advanced engineering practices, developed since the first "mill type" motor was introduced by Crocker-Wheeler in 1904. With a fine record of continued leadership and accomplishment in this field, Elliott today offers a complete line of mill motors, with ratings up to 625 horsepower, for mill and crane service.

Elliott Mill Motors for heavy-duty mill and crane service, are built in ratings up to 250 hp. Rugged cast steel frame, low-inertial armature, glass-bonded insulation and other features give these motors unexcelled dependability.





Separately force-ventilated form W600 motor.



Totally enclosed vertical mill auxiliary motor for flange mounting.

# PUTS EXTRA POWER IN

*Low Losses.* Electrical losses are minimized through the use of low-loss steel for the armature core, the laminated design of main poles and interpoles, and through superior commutation.

*Effective Cooling.* Internal air is circulated by integrally cast fan blades on rear coil support, conveying heat from commutator, armature core and field coils to the frame, where it is dissipated. Two concentric groups of air ducts within the armature core assure ample ventilation and effective cooling. This efficient method of heat dissipation permits higher motor output and provides greater reserve power for a given frame size.

*Spark-Free Commutation.* Tests up to 300 per cent load show negligible sparking. Generous brush area keeps current density at a conservative rating. Multiflex or split type brushes maintain proper contact with commutator. Brushholders are designed to permit top performance and to give high overload capacity. Accurately broached brush compartments assure free action of each brush. Deep commutator bars of silver-bearing copper provide extra wearing depth.

*Glass-Bonded Insulation.* Armature coils consist of double-glass-covered-wire, insulated from the core with silicone-bonded mica insulation, giving superior electrical and mechanical protection, and lasting resistance to high temperatures, moisture, mill dust and oil.

## ELLIOTT COMPANY

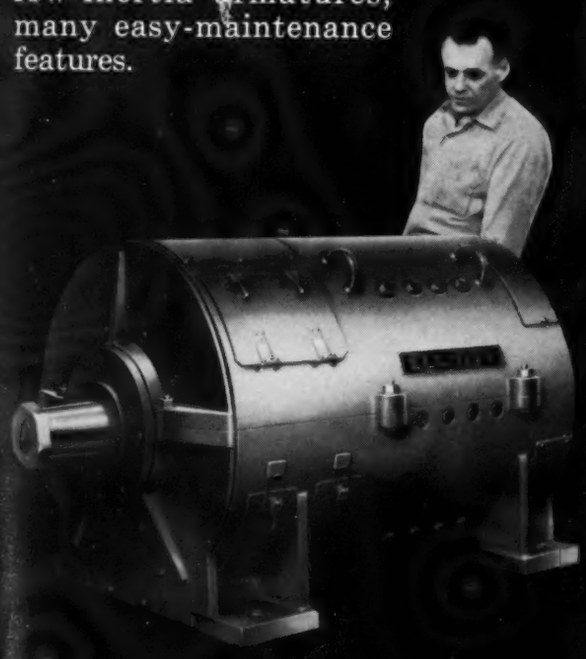
*GENERAL OFFICES: JEANNETTE, PENNSYLVANIA*

*PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio*

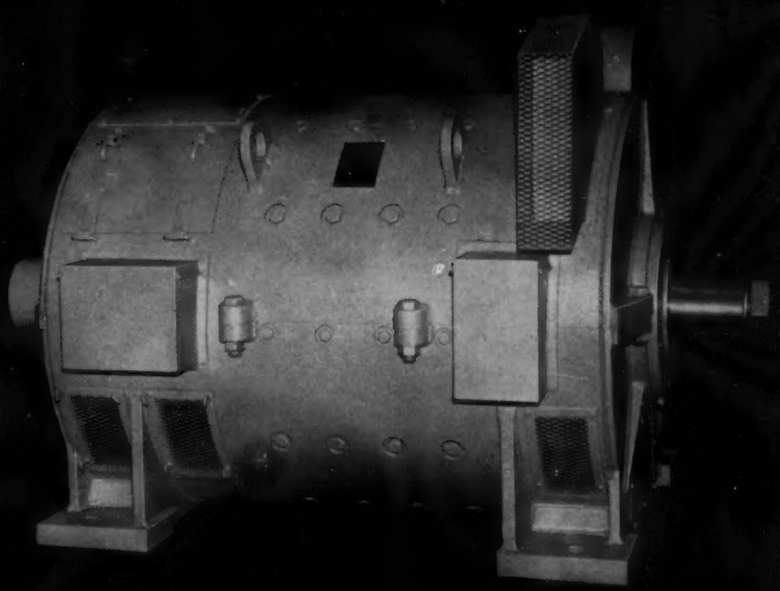
TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS
EJECTORS • STRAINERS • TUBE CLEANERS

W1-1

To meet the need for greater power, Elliott offers 620, 622 and 624 frame Mill Motors shown below. Built in ratings up to 625 hp, these motors have heavy fabricated split steel frames, low-inertia armatures, many easy-maintenance features.

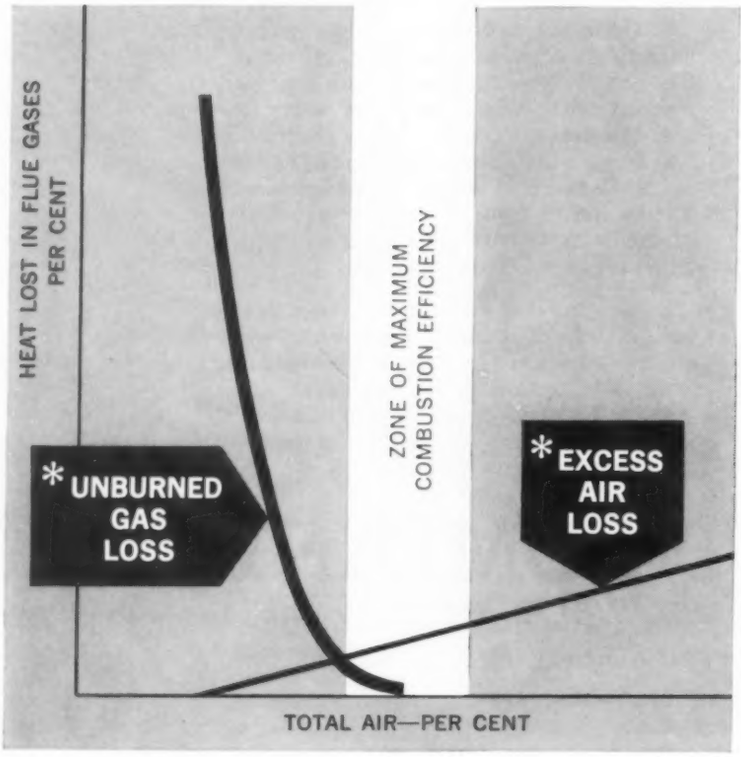


The 620 frame motor in protected, force-ventilated enclosure.



The Elliott 622 frame Mill Motor rated 475 hp at 320 rpm.

# You must know BOTH* to get maximum combustion efficiency!

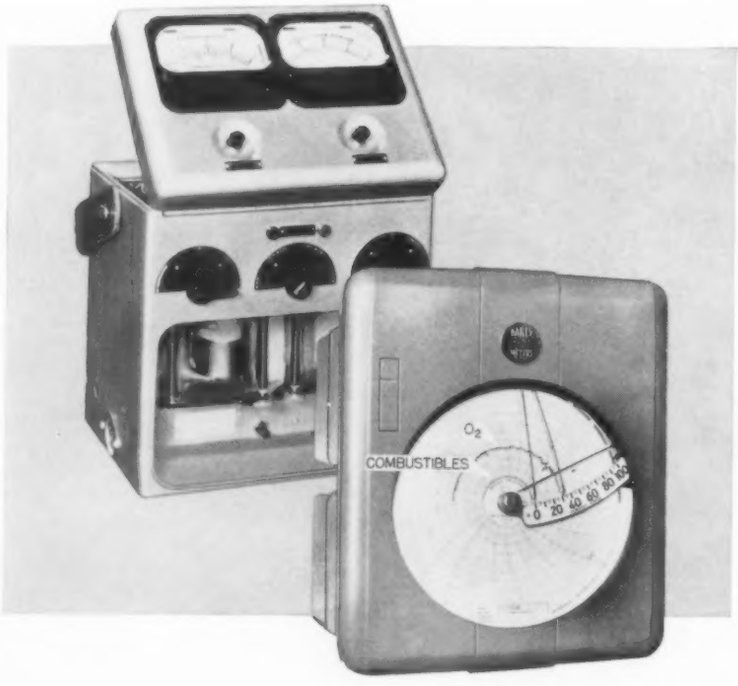

HEAT LOST IN FLUE GASES PER CENT
ZONE OF MAXIMUM COMBUSTION EFFICIENCY
* UNBURNED GAS LOSS
* EXCESS AIR LOSS
TOTAL AIR—PER CENT

How much money is going up the flue in *unburned fuel* losses? Is too much air resulting in excessive *heat* losses?

You must know *both* facts—simultaneously—to get optimum combustion. No instrument that measures only one of these interdependent factors can give you the full information you need.

Bailey offers a choice of two direct ways to maintain a continuous and simultaneous double check on these factors that determine combustion efficiency. The portable, lightweight Bailey HEAT PROVER Analyzer indicates both; the Bailey Oxygen-Combustibles Analyzer-Recorder records both on a single chart. Both instruments measure excess air, regardless of fuel or fuels being burned, and per cent of combustibles in flue gas.

Either of these Bailey instruments can save you far more than their cost in spotlighting combustion inefficiencies. Ask your Bailey engineer or write for product specifications.




**2 DIRECT WAYS to measure both combustibles and oxygen simultaneously**

**PORTABLE INDICATOR**—Self-contained, lightweight, Bailey HEAT PROVER Analyzer enables quick, easy check on combustion conditions. Dual range dials for greater accuracy and readability.

**PERMANENT RECORDER**—Bailey Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart . . . is designed for permanent installation . . . helps maintain optimum ratio continuously.

* Unburned gas loss and excess air loss.

G 155-1

*Instruments and controls for power and process*

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BAILEY METERS

# *Bright Anneal*

## TRIM STOCK AND OTHER STAINLESS STRIP TO A DURABLE MIRROR FINISH

## *without Chrome Depletion*

IN EF CONTINUOUS

## Stainless Strip Bright Annealing FURNACES

### *Many Outstanding Advantages*

✔ **DESIGNED AND BUILT BY THE WORLD'S MOST EXPERIENCED BUILDER OF STAINLESS STRIP BRIGHT ANNEALING FURNACES.** 21 efficient, high production lines installed or under construction. EF has more installed capacity, and more experience in bright annealing stainless strip than any other furnace manufacturer.

✔ **VERTICAL OR HORIZONTAL DESIGNS**— whichever best suits your building conditions and specific production requirements.

✔ **FUEL FIRED OR ELECTRICALLY HEATED**— to use whichever heat is most economical in your plant. No restriction on width. Electric furnaces heated with our proven cast alloy resistor elements; assuring highly efficient heating. None better.

✔ **EF JET OR STATIC COOLING**— jet or combined jet and static cooling, shortens the cooling section.

✔ **HYDROGEN, DISSOCIATED AMMONIA OR VACUUM PROCESSING.** Continuous vacuum furnaces, one of EF's latest developments, save on overall installation and operating cost.

✔ **COMPLETE UNIT RESPONSIBILITY**— furnished completely erected with all controls, terminal equipment and product handling, ready for immediate on-line operation.

For the highest finish, and most durable corrosion resistant surface, contact the EF heat treating engineers. *You'll find it pays.*

THE ELECTRIC EF FURNACE CO. GAS • OIL • ELECTRIC

**THE ELECTRIC FURNACE CO.**

**Fuel Fired and Electrically Heated HEAT TREATING FURNACES for Processing any Product, in any Atmosphere, any Hourly Output Required**

*Salem - Ohio*

**SUBSIDIARIES**—Turnkey Engineering Co., Inc., South Gate, Cal. • Canefco Limited, Scarborough, Ontario

**SALES REPRESENTATIVES**—2842 West Grand Blvd., Detroit 2, Mich. • also 968 Coleman Rd., Cheshire, Conn.

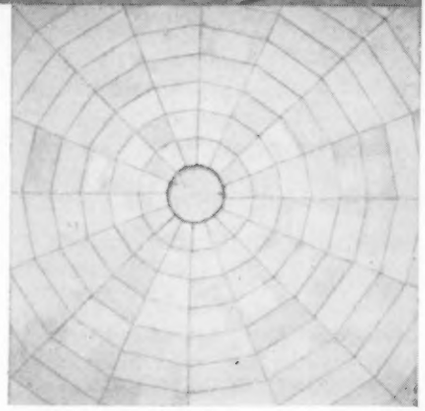
# Bell-type annealing furnaces hold critical temperatures better—using J-M Superex

**LEE WILSON ENGINEERING COMPANY, INC., STANDARDIZES ON J-M SUPEREX BLOCK INSULATION FOR PRECISION AND PERFORMANCE**

In heat-treating furnaces, at temperatures to 1900F, Johns-Manville Superex® Block insulation provides greater efficiency and long operating life . . . because of its unique combination of low conductivity and low shrinkage at elevated temperatures. Control of critical processing temperatures is reached *and held* more easily.

Especially formulated from diatomaceous silica and asbestos, the large, strong, lightweight blocks of J-M Superex are cut with such careful precision that a furnace dome will support the weight of several workers during construction...*without any cement being used!*

This ideal combination of performance advantages and production skill is the reason Lee Wilson Engineering Co., Inc., employs J-M Superex for wall and dome insulation. It will pay you to insist on J-M Superex in your high-heat equipment. Write for details to Johns-Manville, Box 14, N. Y. 16, N. Y. In Canada: Port Credit, Ont. Cable: JOHNMANVIL.



**Inside Looking Up** ...*view from below the dome of a Lee Wilson bell-type furnace. Note close fitting between Superex blocks. This dome actually supports installation workers' weight* . . . without use of cement!

ONLY J-M SUPEREX BLOCK INSULATION GIVES YOU ALL THESE ADVANTAGES:

**High Compressive Strength** – only ⅛" compression under 85 lbs psi

**Low Conductivity** – .82 at 1000F mean temperature

**Low Heat Shrinkage** – 2.7% linear shrinkage at 1900F

**Large Size Blocks** – 12" x 36" blocks speed application, reduce number of joints. Yet blocks are light in weight for ease of installation

**Lightweight** – only 24 lbs per cubic foot

# JOHNS-MANVILLE

AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

JOHNS-MANVILLE JM PRODUCTS

# Pre-Engineering by **KAISER ENGINEERS** answers basic plant expansion questions...

## Raw Materials?

Your final decision to expand or build results from a series of important individual decisions. Raw material availability is one of them. Independent analysis of all aspects of your proposed program is the *Pre-Engineering* service offered by Kaiser Engineers. In addition, KE designs and builds for the Steel industry... offers skilled experience in all types of facilities from raw material plants to finishing mills. Whatever your requirements... from Pre-Engineering analyses through plant design and construction... Kaiser Engineers brings world-wide experience and ingenuity to their solution.

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6231-S

# National rewinds steel mill motor during vacation shutdown ...completes job with 1 day to spare

"Thanks for a job well done" reported the customer after National Electric Coil completed this major motor rewinding a day ahead of schedule.

The timetable was very tight, as the 3500 H. P. unit drives the main reversing mill. All work had to be accomplished during a planned mill shutdown, with time allowed after installation for acceptance tests.

**National's preplanning** took into account the following unusual operations:

- Top half of the field frame had to be unbolted and slid over to one side as there was no crane at the location adequate in capacity to lift the frame.
- The armature, while in its own bearings, was stripped, cleaned, and rewound with NECCOBOND coils – all coils and winding supplies having been manufactured in advance to expedite installation.
- A special gear and brake were fabricated to permit turning the armature during installation.
- The commutator was turned and undercut and the armature banded before final reassembly of the motor.

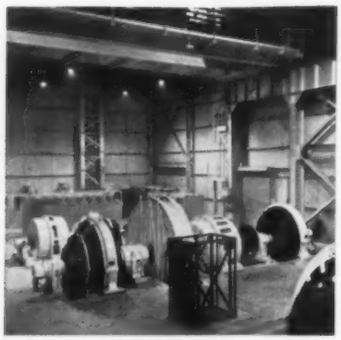
For a "well-done" job on your rotating electric machinery rebuilding or service needs, contact National Electric Coil. Our service is fast, thorough and dependable. Call National's Columbus plant, HUdson 8-1151, or check the nearest National field engineer.

NATIONAL COILS

**National Electric Coil**

COLUMBUS 16, OHIO • IN CANADA: ST. JOHNS, QUEBEC

DIVISION OF McGRAW EDISON



*Electrical equipment operates in "surgically-clean" air, filtered through Wheelabrator Ultra-Filtration equipment. No down-time for motors and generators. No maintenance for the air filter. Send for bulletin 562-D.*

# surgically clean air keeps motors healthy at ACME STEEL

*A demonstration of WHEELABRATOR'S*

# VITAL VALUES

"Surgically-clean" air, delivered by Wheelabrator Ultra-Filtration equipment at 135,000 cfm, keeps equipment humming in the blooming mill motor and control room at the new Riverdale, Ill., plant of Acme Steel Company. In more than a year, no breakdown of electrical equipment has been caused by air-borne dust or dirt. Absolutely no maintenance—not even a filter change—has been required for the Ultra-Filtration equipment in the years it has been operating. Wheelabrator's high-efficiency air filters result in savings in investment, installation, operation, and maintenance. Look to Wheelabrator for the Vital Values of more and bigger savings.

VITAL VALUES FOR INDUSTRY

**WHEELABRATOR** DUST AND FUME CONTROL

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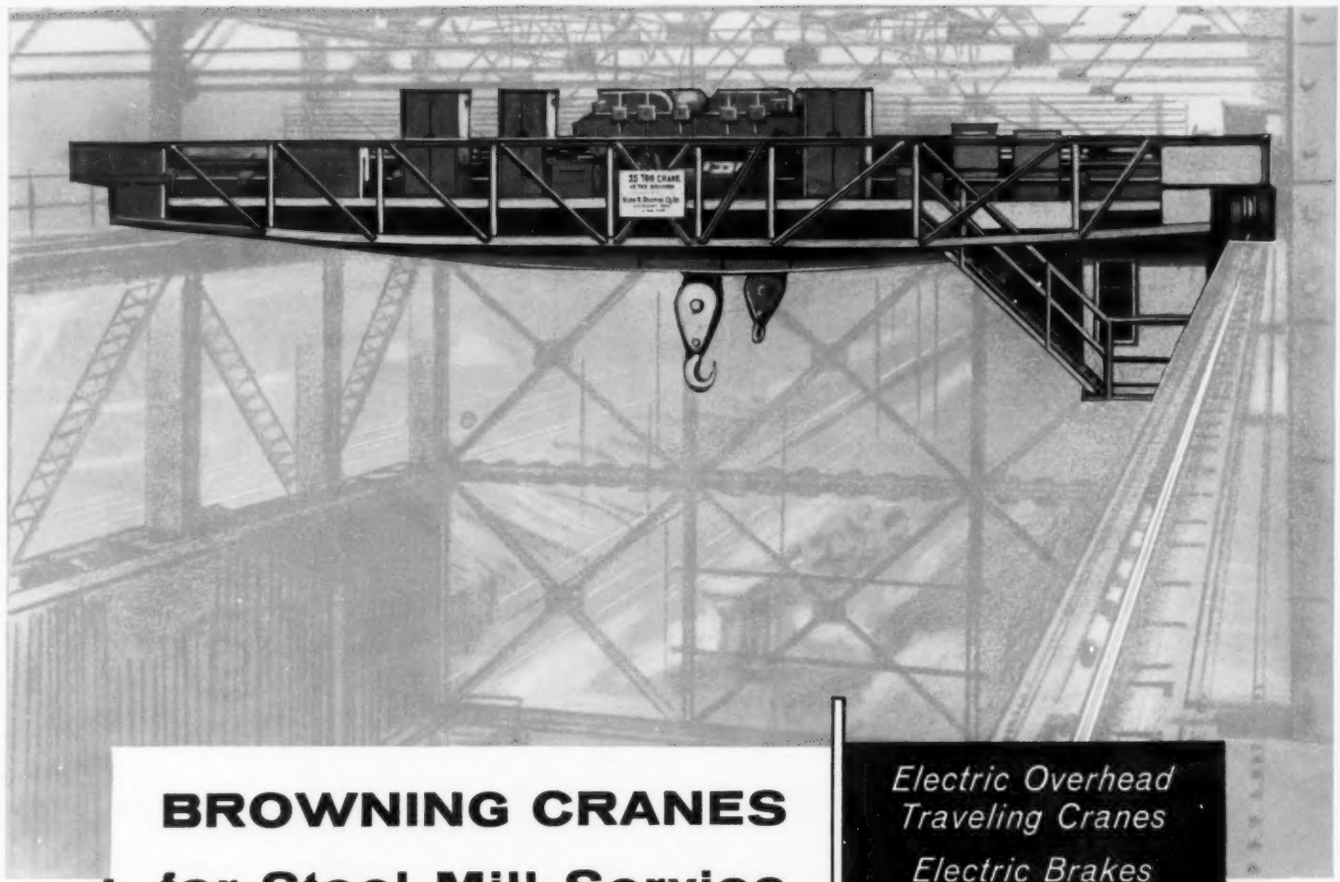
A subsidiary of Bell Intercontinental Corp.



# BROWNING CRANES for Steel Mill Service and General Industrial Service

*Electric Overhead Traveling Cranes*
*Electric Brakes*
*Buckets*
*Electric Revolving Machines*
*Special Trolleys*

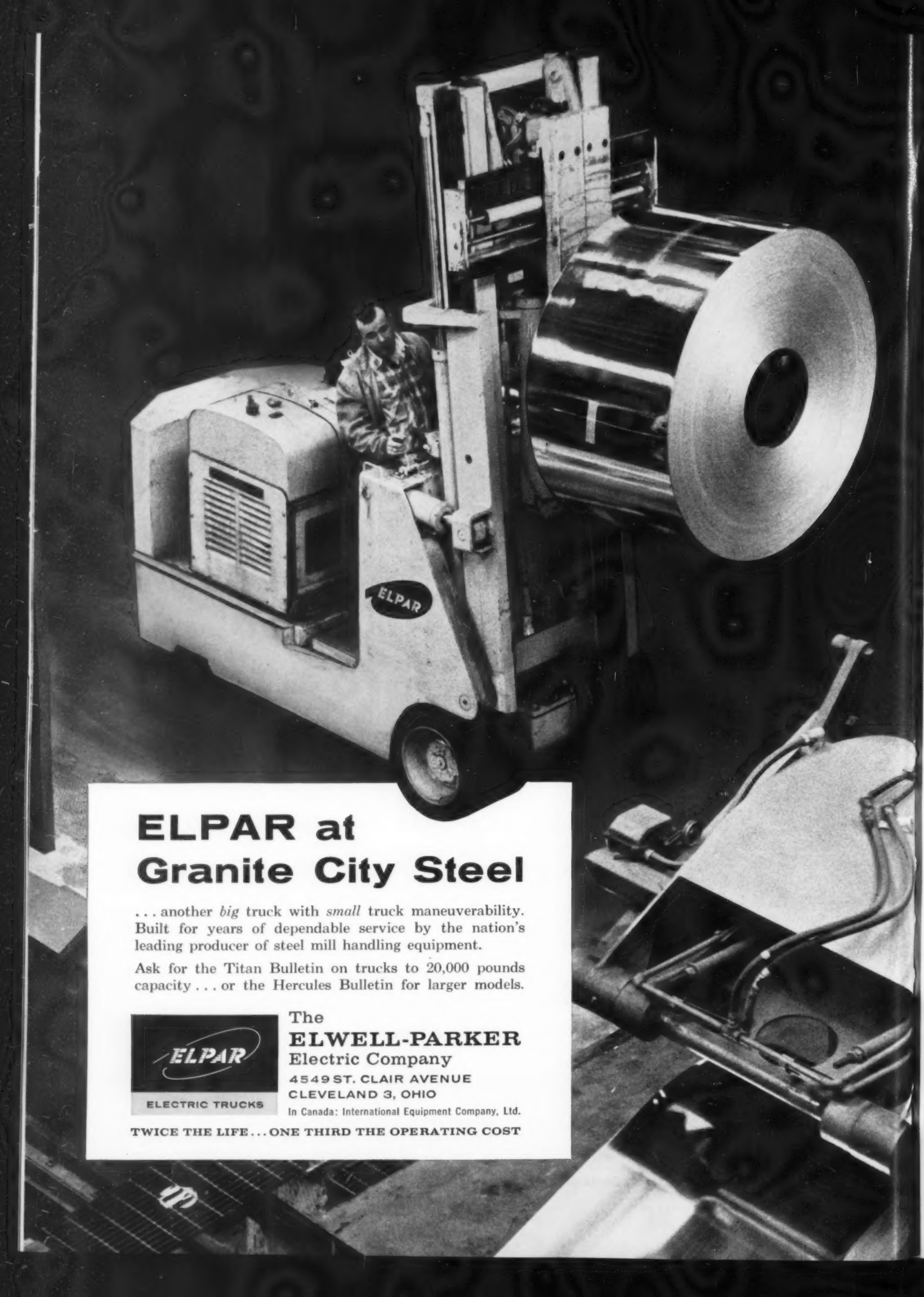
Browning cranes are designed and built specifically for heavy duty mill type and industrial service. Mill type cranes meet or exceed AISE requirements. We build into every crane whatever special features, mechanical or electrical, which you may desire.

Information worth your having:

(1) our complete well illustrated catalog describing Browning cranes, trolleys, brakes, hook blocks;
(2) separate bulletin on Browning brakes.

**VICTOR R. BROWNING & COMPANY, INC.**

**WILLOUGHBY (CLEVELAND), OHIO**




# ELPAR at Granite City Steel

. . . another *big* truck with *small* truck maneuverability. Built for years of dependable service by the nation's leading producer of steel mill handling equipment.

Ask for the Titan Bulletin on trucks to 20,000 pounds capacity . . . or the Hercules Bulletin for larger models.

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In Canada: International Equipment Company, Ltd.

**TWICE THE LIFE . . . ONE THIRD THE OPERATING COST**

# patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

*Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D.C., at 25 cents . . . . patents reviewed cover period November 22, 1960, to December 13, 1960*

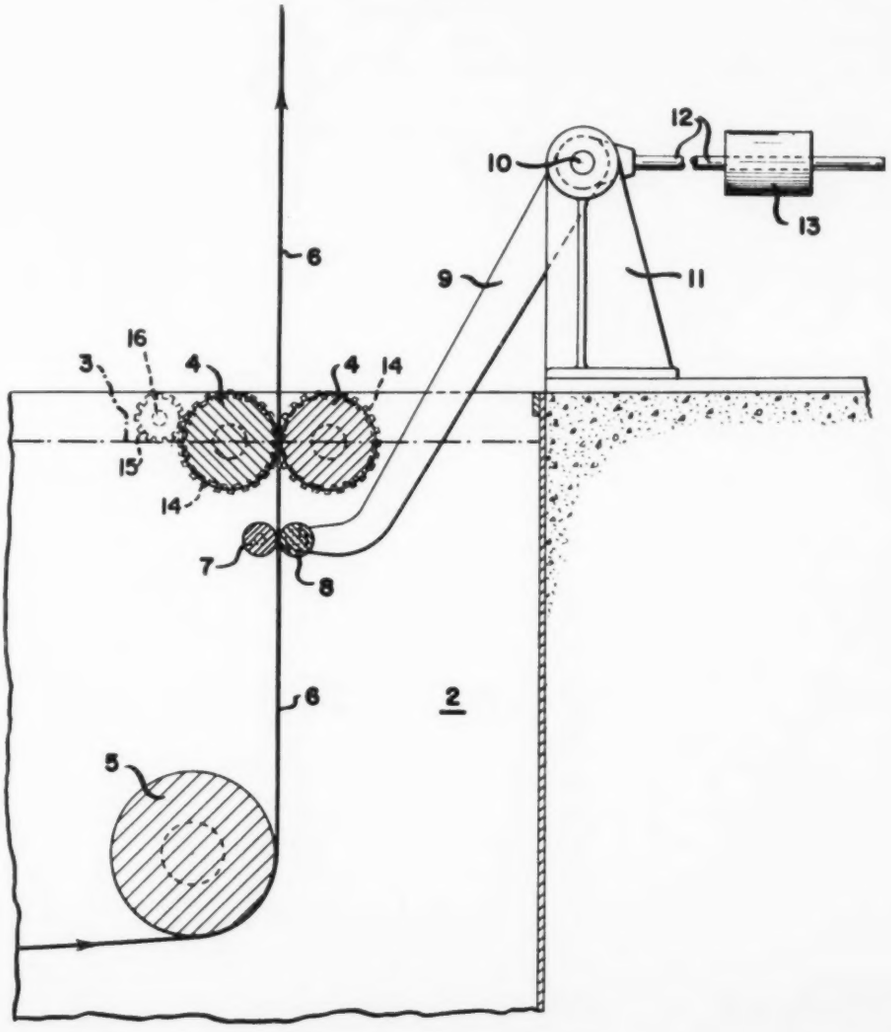
### CONTINUOUS HOT DIP GALVANIZING OF METAL STRIP

△ U. S. 2,952,568, issued Sept. 13, 1960, to William L. Diehl and Henry S. Bell, assigned to Wheeling Steel Corp., relates to the continuous hot dip galvanizing of metal strip and more particularly to an improved process which contributes importantly to the ability to produce galvanized strip of optimum quality at unprecedented speed.

It has been found that the tendency of the strip to carry an excessive amount of molten spelter up out of the bath when the strip speed increases can be counteracted by regulating the drive of the exit rolls so that the exit rolls inhibit the movement of spelter upwardly between the rolls relatively to the effect of the exit rolls upon upward movement of the spelter when the exit rolls are normally driven. The faster the speed of the strip and the thinner the coating desired the greater should be the difference between the speed of the strip and the speed of the exit rolls. The exit rolls should be driven at a speed slower than the speed of the strip.

Another factor which causes difficulty is the capillary attraction of the strip for the spelter. The exit rolls will break down the capillary attraction to a certain extent but their ability to do so is lessened as the strip speed and coating thickness increase. It has been found highly desirable to provide means engaging the strip in the molten spelter bath before the strip reaches the exit rolls to inhibit the tendency of spelter to cling to the strip, or, in other words, to break down the capillary attraction of the strip for the spelter. Thus rolls are brought to bear against the faces of the strip

Figure 1



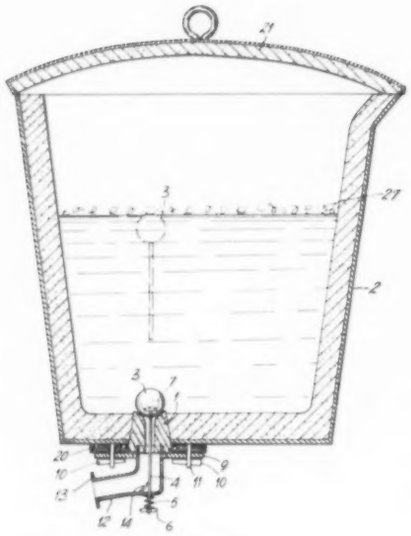


Figure 2

in the bath before the strip reaches the exit rolls, as shown in Figure 1.

### BLOWING GASES INTO A BATH OF MOLTEN METAL

△ U. S. 2,956,794, issued Oct. 18, 1960, to Marc Allard and assigned to Institut de Recherches de la Siderurgie, provides a method of blowing gas such as oxygen (also containing pulverulent material, if desired) into a bath of molten metal such as pig iron, without the use of a lance.

As shown in Figure 2, a nozzle 1 made of refractory material is fitted in the bottom of the ladle 2, while a closing plug or pad 3 engages, when in its closing position, the upper end of the nozzle 1 over which it is held by a rod 4 urged downwardly by a spring 5 bearing against the key 6 passing through the rod 4. Plug 3 may be suddenly released by removing the securing means in the form of key 6 so as to open the communication between the channel extending through the nozzle 1 and the metal bath carried in the ladle, the plug 3 rising then to the upper level of the ladle, as illustrated in dot and dash lines. Plug 3 is made of a material having a specific gravity smaller than that of the molten metal.

When the injection pressure of the gas is reduced to zero, the liquid metal becomes solid inside the injection channel, thereby closing the nozzle. Alternatively, a stopper rod may be used.

### INGOT MOLD

△ U. S. 2,957,213, issued Oct. 25, 1960, to William W. Schofield, William H. Owen and John Bidner, provides improvement in big-end-up ingot molds for casting steel ingots.

The mold is shown in Figure 3. It has a wall thickness greater at the top of the mold cavity and of gradually decreasing thickness downwardly of the mold, a ratio of mold wall area to ingot area below 1.20 to 1 over the entire vertical height of the mold, the ratio being as low as 0.70 to 1 in the lower wall portion of the mold, and an integral pedestal base on the mold. The size of the pedestal has a ratio with the size of the top of the mold in substantially direct proportion to the ratio of the wall area of the top of the mold with respect to ingot area at the top of the mold. Further, as the lower mold area is reduced in relation to the lower ingot area from a ratio of about 0.90 to about 0.70 to 1, the size of the pedestal base is increased in area by an amount equal to about one half of the reduction in area of the lower mold wall.

The reduction in the mold wall thickness materially decreases the weight of the ingot mold and its cost, but it has been likewise discovered that the reduction in wall thickness does not adversely affect, and in fact enhances, the cooling of the ingot from the bottom upwardly to reduce the piping in the ingot. This is believed due to the fact that the less amount of metal

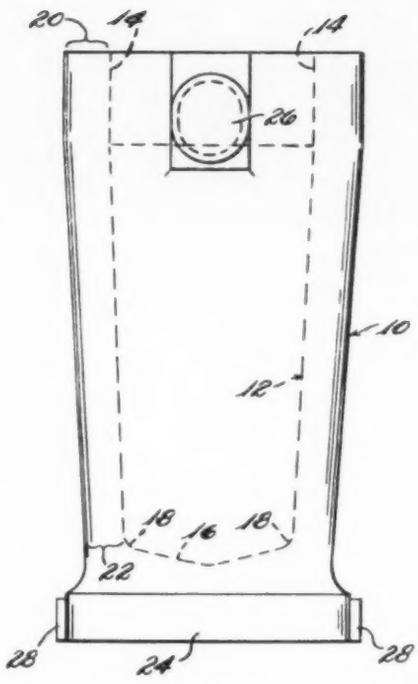


Figure 3

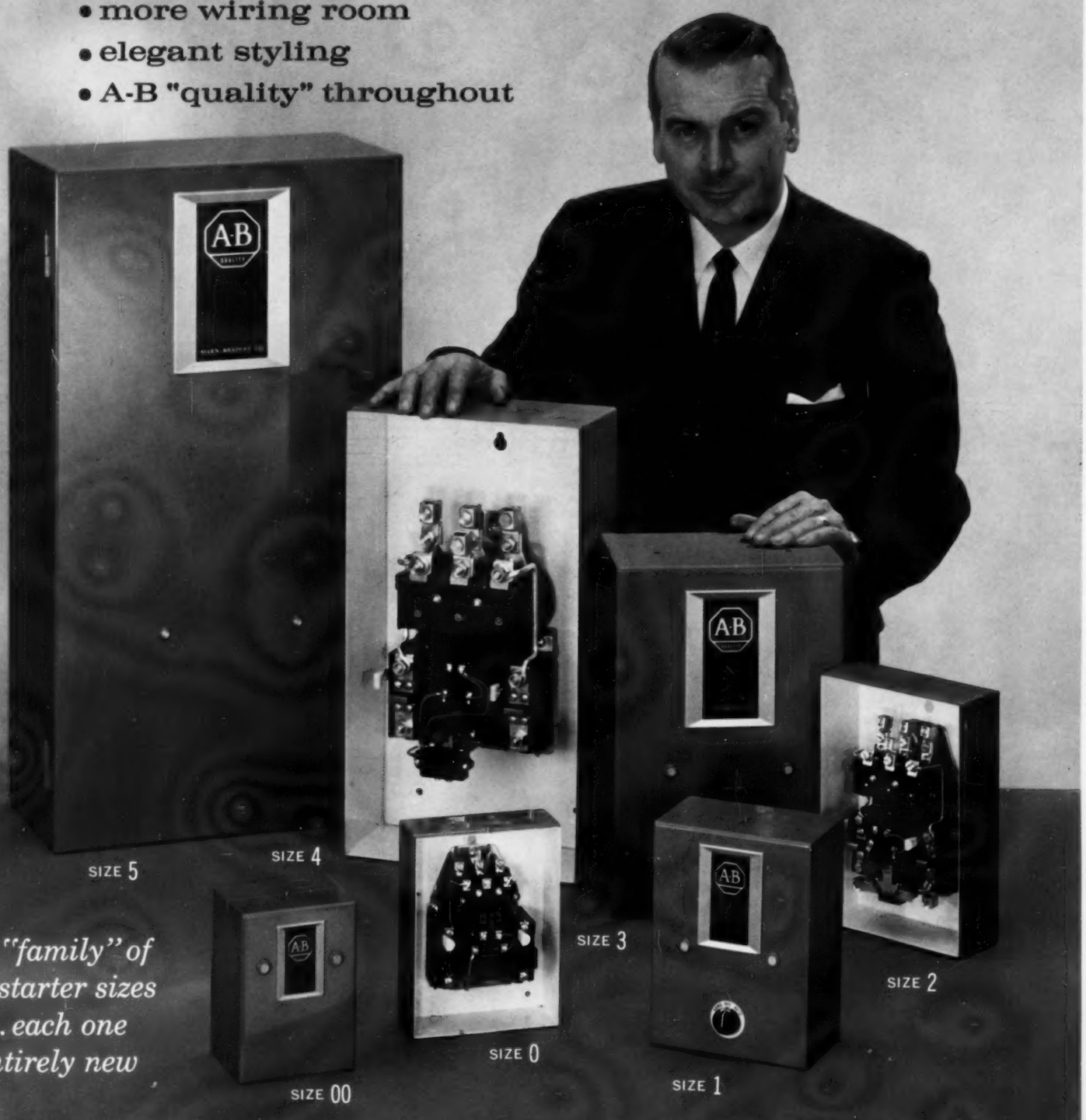
in the lower wall of the ingot mold tends to avoid storing the heat in the bottom end of the ingot, and allows this heat to radiate more easily to the outside air surrounding the mold and speeds up the freezing of the ingot from the bottom end upward. The greater amount of wall thickness and metal in the upper portion of the ingot mold insures that the ingot gradually solidifies from the bottom upwardly and freezes last at the top of the mold.

### OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

| Patent No. | Date | Subject | Inventor or Assignee |
|---|---|---|---|
| 2,961,065 | 11/22/60 | Coke-oven gas by-product recovery | Koppers Co., Inc. |
| 2,961,232 | 11/22/60 | Sintering apparatus | Anders Holmberg, et al. |
| 2,961,298 | 11/22/60 | Extraction of iron from titaniferous raw materials | Nils K. G. Tholand |
| 2,961,336 | 11/22/60 | Hot-coating strip materials with paints or enamels | National Steel Corp. |
| 2,961,691 | 11/29/60 | Grommet for guiding wire | United States Steel Corp. |
| 2,961,721 | 11/29/60 | Machine for making hot tops | Aktiebolaget Svenska Kullagerfabriken |
| 2,961,741 | 11/29/60 | Hydraulic descaler | American Steel Foundries |
| 2,961,742 | 11/29/60 | Descaling heated bar or wire stock | Friedrich B. Hatebur |
| 2,961,761 | 11/29/60 | Production of clad steel plates by the 2-ply method | Lukens Steel Co. |
| 2,961,901 | 11/29/60 | Automatic control for adjusting rolling mills | Stephen W. Wheeler, et al. |
| 2,962,175 | 11/29/60 | Blast furnace charging controller | Cutler-Hammer, Inc. |
| 2,962,779 | 12/6/60 | Teeming nozzle valve for vacuum casting apparatus | United States Steel Corp. |
| 2,962,781 | 12/6/60 | Preparing a sand mold for an ingot mold | United States Steel Corp. |
| 2,962,811 | 12/6/60 | Method of making stainless steel honeycomb panels | Rohr Aircraft Corp. |
| 2,962,917 | 12/6/60 | Rolling mill guides | United States Steel Corp. |
| 2,963,221 | 12/6/60 | Extensometer | United States Steel Corp. |
| 2,963,364 | 12/6/60 | Manufacture of cast iron | Air Reduction Co., Inc. |
| 2,964,203 | 12/13/60 | Coil stripping apparatus | Bethlehem Steel Co. |
| 2,964,434 | 12/13/60 | Pickling and rust-inhibiting bath for ferrous metals | Victor Chemical Works |

# a new line of Bulletin 709 motor starters by ALLEN-BRADLEY

- smaller size
- greater interrupting capacity
- even more millions of trouble free operations
- more wiring room
- elegant styling
- A-B "quality" throughout




*A "family" of 7 starter sizes . . . each one entirely new*

# greatest advance in motor control in 30 years

A-B QUALITY

In appearance . . . in performance . . . in physical size and weight . . . these Allen-Bradley Bulletin 709 solenoid starters are *completely new in every way!*

**NEW COMPACTNESS.** Size reductions are so drastic you'll hardly believe your eyes. The tables below will give you some idea of how the new line of Bulletin 709 starters compares with the old.

**A TREMENDOUS INCREASE IN LIFE**—both mechanical and electrical. All of these new starters are good for many more millions of trouble free operations.

**NEW PATENTED MAGNET.** For its weight and size, the most powerful magnet used on motor control. Its short, cushioned stroke assures long contact life. A new, permanent air gap prevents any possibility of magnetic sticking. "Snap action" guarantees positive contact opening and closing.

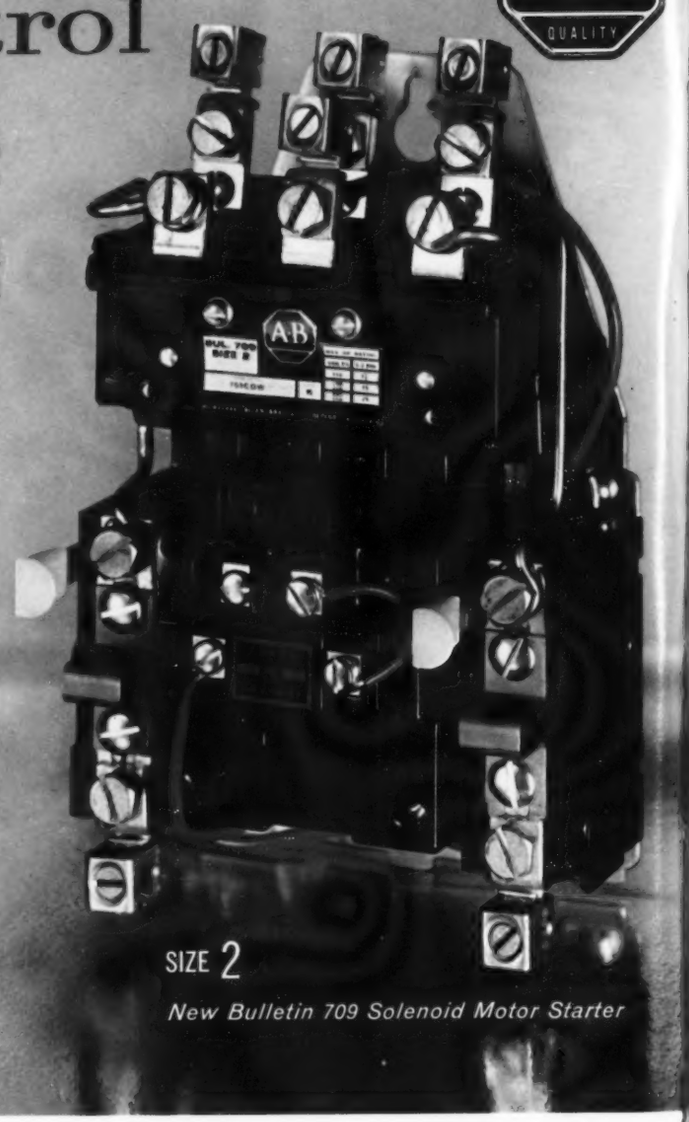
**NEW MOLDED COIL.** Impervious to atmospheres that could cause trouble, and also protected against mechanical damage. All coils are easily removed—from the front of the starter.

**NEW CONTACTS.** New double break contacts of cadmium oxide silver resist welding . . . close and seat firmly without sliding or wear-causing motion.

**NEW OVERLOAD RELAYS.** Not only "trip-free" but also "tamperproof," to reliably protect motor and machines. Of course the new relays were designed to use the old Bulletin 709 heating elements which you have in stock.

**NEW ENCLOSURES.** Completely restyled by Brooks Stevens—and so modern. They are a sales asset on any type of modern machine or industrial installation.

**BETTER WRITE FOR MORE INFORMATION ON THIS REVOLUTIONARY NEW BULLETIN 709 STARTER!**



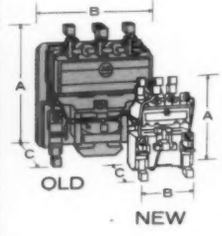
SIZE 2

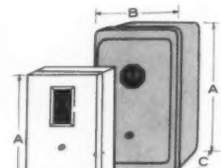
*New Bulletin 709 Solenoid Motor Starter*

## CHECK THE "NEW" WITH THE "OLD" BULLETIN 709 DIMENSIONS

The wiring room in the new enclosures will delight the electrician.

| Starter Size | OPEN TYPE STARTERS | | | | | |
|---|---|---|---|---|---|---|
| | NEW | | | OLD | | |
| | Height A | Width B | Depth C | Height A | Width B | Depth C |
| 00 | 3⅝ | 3⅞ | 3⁹⁄₁₆ | — | — | — |
| 0 | 5⅞ | 4⅛ | 3¹¹⁄₁₆ | 5⅝ | 4¾ | 3¼ |
| 1 | 6⅝ | 4½ | 3¹¹⁄₁₆ | 5⅞ | 5 | 3¼ |
| 2 | 7¾ | 4⅝ | 3¹¹⁄₁₆ | 10⅛ | 5¾ | 4⅞ |
| 3 | 10¼ | 6¼ | 5⅞ | 12⅝ | 7¼ | 5⅞ |
| 4 | 11⅞ | 7⅜ | 6¼ | 16¼ | 12¾ | 6¹⁵⁄₁₆ |
| 5 | 14¹³⁄₁₆ | 9 | 6½ | 20 | 16⅛ | 8¾ |




| Starter Size | NEMA 1 ENCLOSURES | | | | | |
|---|---|---|---|---|---|---|
| | NEW | | | OLD | | |
| | Height A | Width B | Depth C | Height A | Width B | Depth C |
| 00 | 7⅝ | 4⅞ | 4¼ | — | — | — |
| 0 | 9⅛ | 6⁵⁄₁₆ | 4⅜ | 7⅞ | 5⅝ | 4¼ |
| 1 | 10 | 6¹³⁄₁₆ | 4⅜ | 8¹³⁄₁₆ | 6⅜ | 4¼ |
| 2 | 12 | 7⅝ | 4⅜ | 14½ | 9 | 5⅞ |
| 3 | 16⅝ | 10⅜ | 7 | 19½ | 11⅜ | 6¹¹⁄₁₆ |
| 4 | 22 | 11⅝ | 8 | 26⅞ | 14³⁄₁₆ | 7¹¹⁄₁₆ |
| 5 | 32³⁄₁₆ | 17³⁄₁₆ | 9⅞ | 41½ | 19⁹⁄₁₆ | 13⁹⁄₁₆ |

8-61-RM

# ALLEN-BRADLEY

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*Quality Motor Control*

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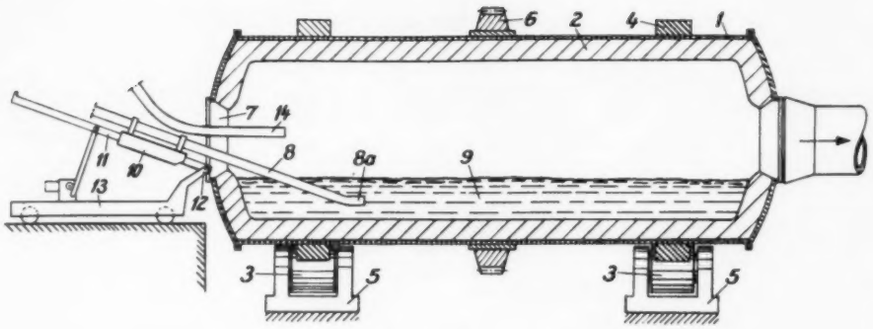



Figure 4

### METHOD OF MAKING STEEL

△ U. S. 2,959,479, issued Nov. 8, 1960, to Rudolf F. Graef and assigned to Huttenwerk Oberhausen A.G., provides a method of making steel low in nitrogen, by blowing oxygen in a horizontal rotating drum.

The thermal efficiency of the method has been increased by introducing oxygen not only into the bath, but also, as shown in Figure 4, above the bath surface to burn the carbon monoxide evolved during the refining process.

Furthermore, it has been found that it is not necessary to use oxygen for the combustion of the carbon monoxide. Ordinary air may be used for this purpose, without increasing the nitrogen content of the steel.

### BENEFICIATION OF MAGNETIC IRON ORES

△ U. S. 2,962,231, issued Nov. 29, 1960, to David Weston, relates to milling operations used in the beneficiation of magnetic iron ores.

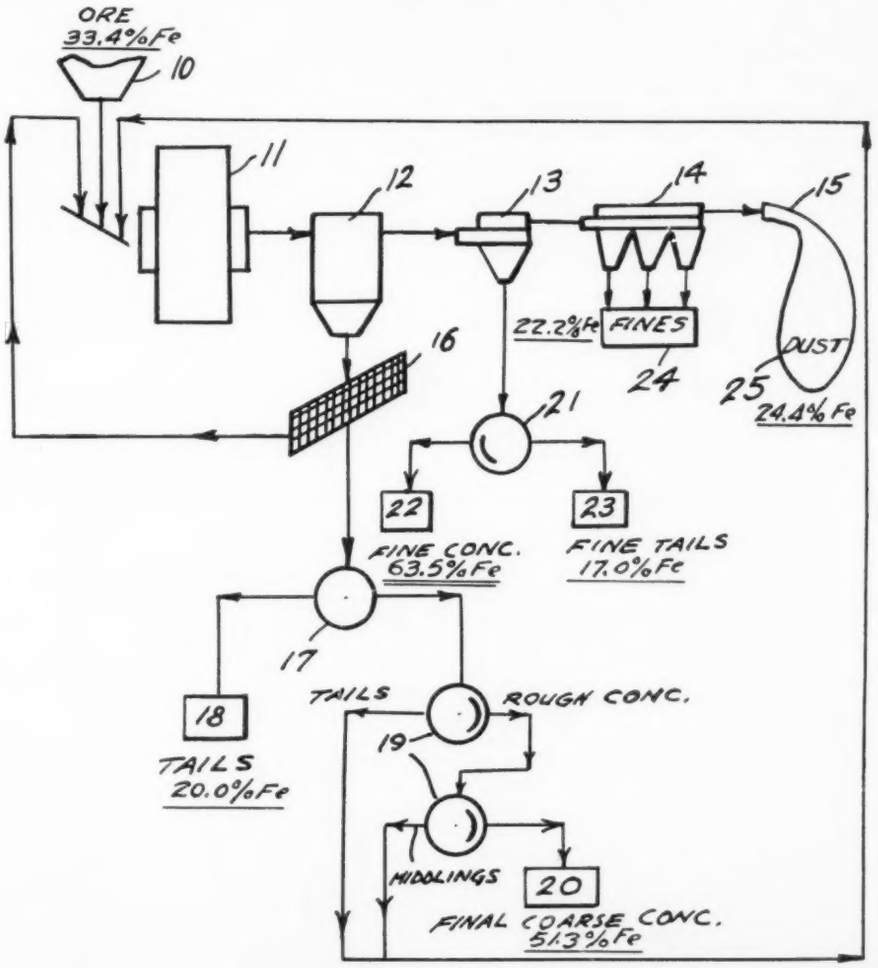
As shown in Figure 5, feed 10 is delivered to the combined dry crushing and grinding unit 11 which is an air-swept mill discharging into an air classifier 12 which removes the oversize and permits the main product to pass to cyclone 13. After a deposit of the main product in cyclone 13, fines are collected in the multicyclone 14 and dust which is too fine for collection in the multicyclone 14 is collected in the bag filter 15. The air classifier 12 discharges on to the mechanical screen 16 and the oversize from the screen is returned to the inlet side of the mill. The through product from screen 16 is passed to magnetic separator 17 which produces a final tailing 18 of low metal content (20.0 per cent Fe) and a rough concentrate of higher metal content which is passed to a second magnetic concentrator 19, which latter produces a final coarse concentrate 20 containing 51.3 per cent Fe and a minor proportion of tailings and middlings which are combined and recirculated to the inlet side of the mill 11. The main product from cyclone 13 is passed to a magnetic concentrator 21 which produces a final fine concentrate 22 of 63.5 per cent Fe and fine tails 23 containing 17.0 per cent Fe.

### APPARATUS FOR CHARGING OPEN HEARTH FURNACES

△ U. S. 2,962,174, issued Nov. 29, 1960, to Harold F. Shekels, describes apparatus for rapid charging of scrap into an open hearth furnace.

The apparatus is shown in Figure 6. In operation, carriage 10 is moved along tracks 6 and 8 until it is positioned in front of one of the doors 4 of the open hearth to be charged. Rail clamps 96 are then actuated to clamp the machine to the rail 6 and prevent vertical movement of the carriage 10. Bridge 30 is then moved away from the furnace 2 by a motor. The cylinders 44, 60 and 88 are then actuated so as to move the chute 78 and hopper 82 to a position with the hopper 82 resting on the floor. Large quantities of prepared scrap or other furnace additions are then dumped into the hopper 82 by any suitable equipment such as a truck. Cylinders 44, 60 and 88 are then actuated to bring the hopper 82 and chute 78 to a horizontal position on bridge 30.

Figure 5



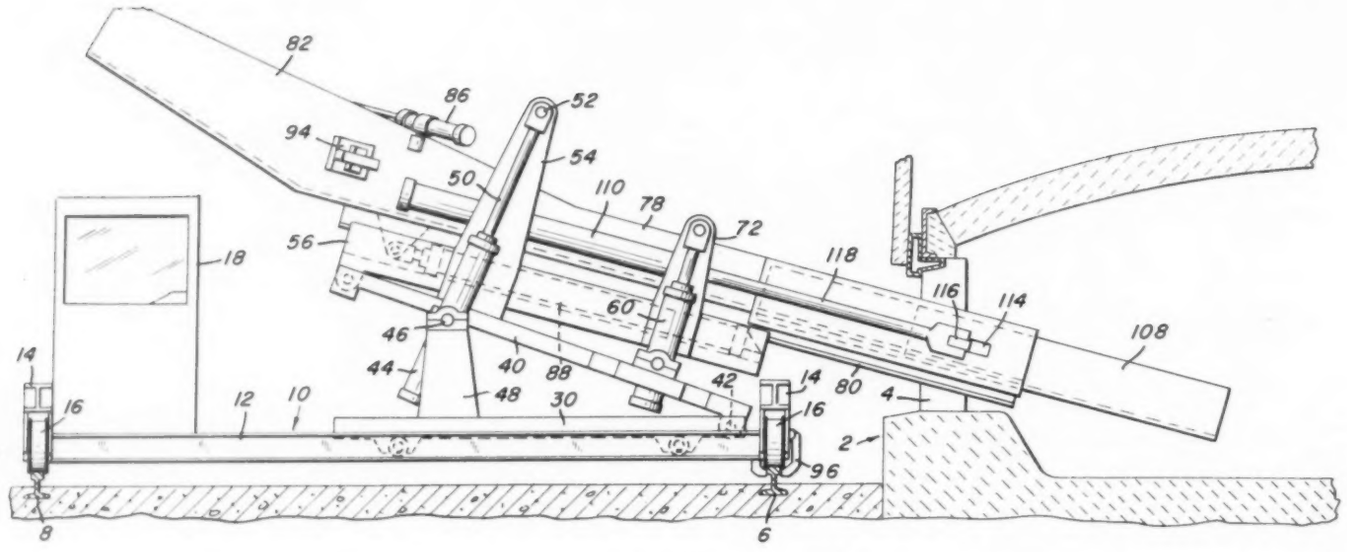



Figure 6

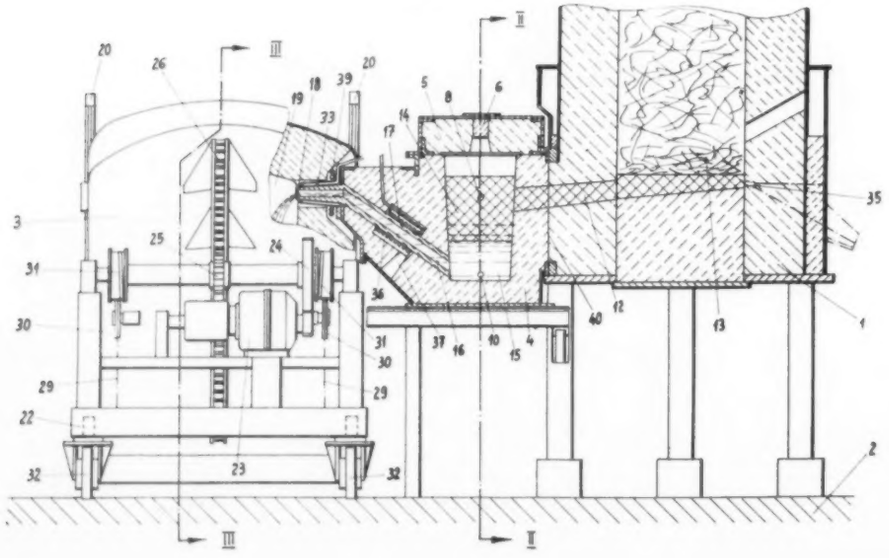
The bridge 30 is then moved forward, toward the furnace 2 by means of a motor with the forward end of the chute extending into the furnace 2. The cylinders 44, 60 and 88 are then actuated to move the chute 78 into the furnace with the rearward end of the chute being elevated as shown in Figure 6. If an extension 108 is necessary, it will have been moved forward by means of cylinders 110 as shown. Thus, regardless of whether an extensible or nonextensible chute is used, the forward end of the chute will be positioned adjacent the bottom and back of the furnace. Doors in hopper 82 are then opened by means of cylinders 86 and vibrators are actuated so that the scrap is charged into the furnace. The chute is gradually withdrawn until the hopper is emptied and that portion of the furnace fed through the door 4 is charged. The chute 78 is then returned to a horizontal position on the bridge 30, the rail clamps 96 are released and the carriage 10 is moved along tracks 6 and 8 to the next furnace door where the charging operation is repeated.

## HOLDING APPARATUS FOR MOLTEN METALS

△ U. S. 2,962,278, issued Nov. 29, 1960, to Walter Goetz and Erwin Buhrer, and assigned to Georg Fischer A.G., provides an apparatus in which molten iron is supplied to a mixer.

The apparatus is shown in Figure 7. When the melting unit is started, taphole 10 is open and taphole 8 closed. When a cupola furnace is started, liquid slag is first discharged. As soon as liquid iron flows from the furnace, the taphole 10 is closed. The iron chamber 15 and the ceramic tube 16 rapidly fill with liquid iron, the slag in the slag chamber 14 floating above the iron in iron chamber 15. Since both the iron and slag chambers (14, 15) and the interior of the ceramic tube 16 are well preheated by a burner (not shown) inserted in the opening 6 and removed prior to starting the cupola furnace, there is practically no danger that the iron will solidify on its way into the interior 19 of the mixer.

Figure 7




The induction heating coil 17 heats the iron flowing through the ceramic tube 16 and the outlet tube 18 into the interior 19 of the mixer. The power for the induction heating coil 17 is such that a given tapping temperature of the liquid iron is obtained and the preheating temperature of the mixer 3 after filling is allowed for. In normal cases a power of 15 to 30 kwhr per ton of liquid iron will be required during the starting cycle, which lasts about one hr. When the liquid iron charge in mixer 3 has reached the desired level, liquid iron can be discharged from it for casting. When the same tapping temperature is to be maintained, experience shows that the heating power can be reduced to 0 to 5 kwhr per ton liquid material within one to two hr depending on conditions.

"For workability . . .

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. . . reports Patcher Foreman
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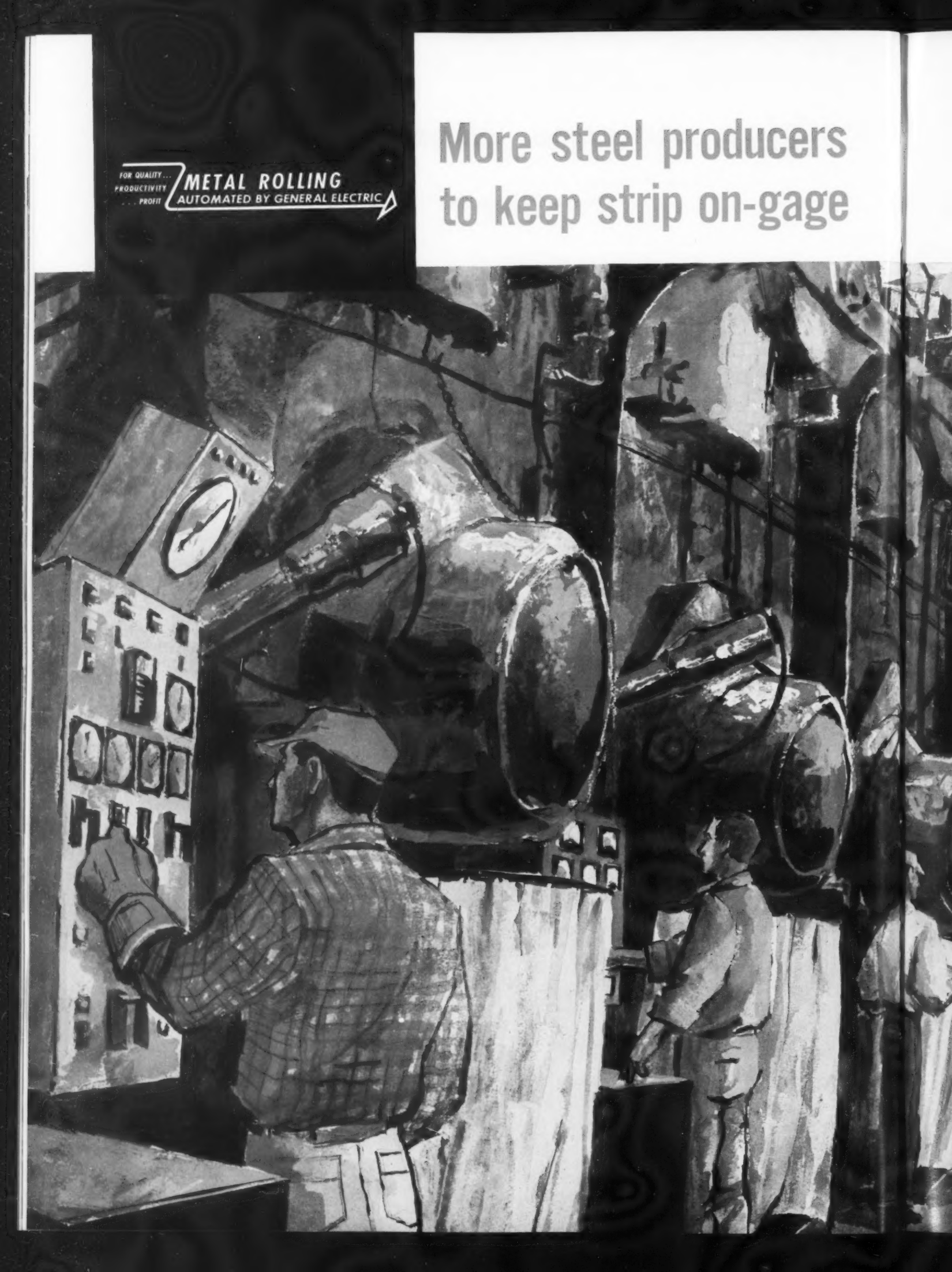
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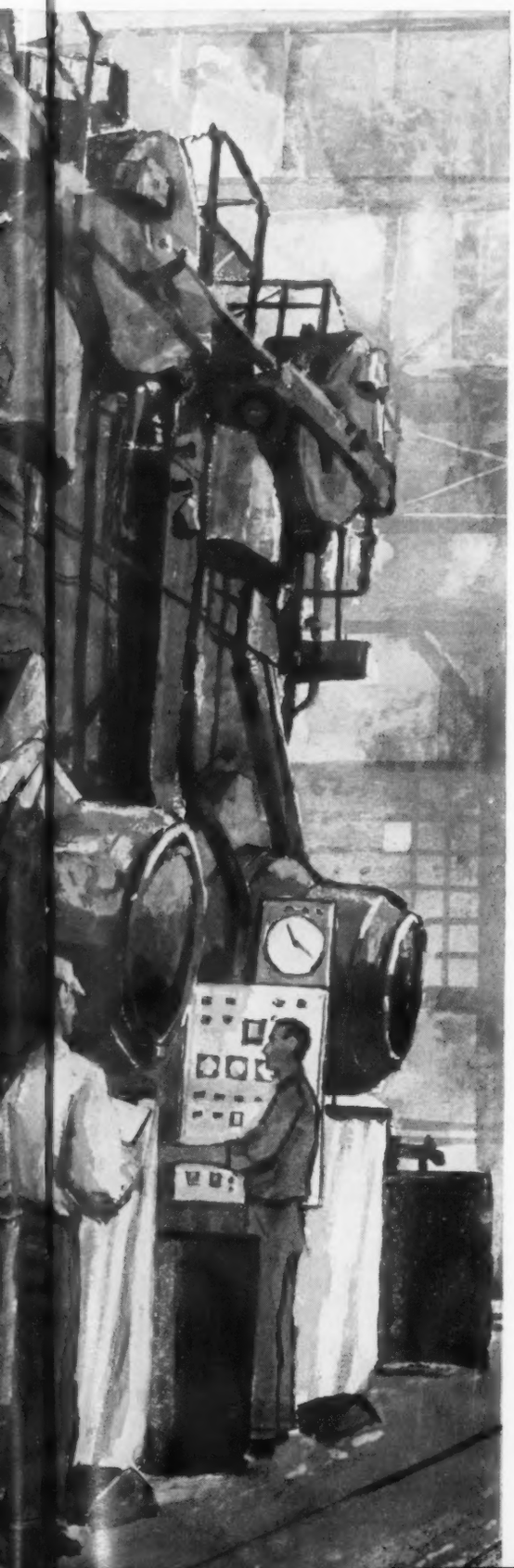
METAL ROLLING
AUTOMATED BY GENERAL ELECTRIC
More steel producers
to keep strip on-gage

# turn to General Electric gage control automatically, increase yield per ton



To maintain strip gage . . . increasing output of saleable product . . . more and more steelmakers are using General Electric automatic gage controls. G-E gage control systems to be delivered in 1961 are equal in number to all automatic systems supplied since the first installation in 1955 . . . bringing to nearly 50 the number of General Electric designed systems in operation. Automatic gage control is another of many products and systems General Electric has pioneered in 75 years of developing and building equipment to help make metal rolling faster, more efficient, and more profitable.

Two automatic gage control systems . . . a cold-mill system first applied in 1955, and a hot-mill system successfully applied in 1958 . . . result in greater yield of usable strip per ton while reducing costly downtime resulting from less-efficient manual adjustment systems. Look at the benefits in these two key areas:

**Higher quality strip**—more uniform strip throughout because off-gage signal automatically activates corrective equipment . . . strip gets on-gage sooner, stays on-gage longer . . . more usable strip per ton.

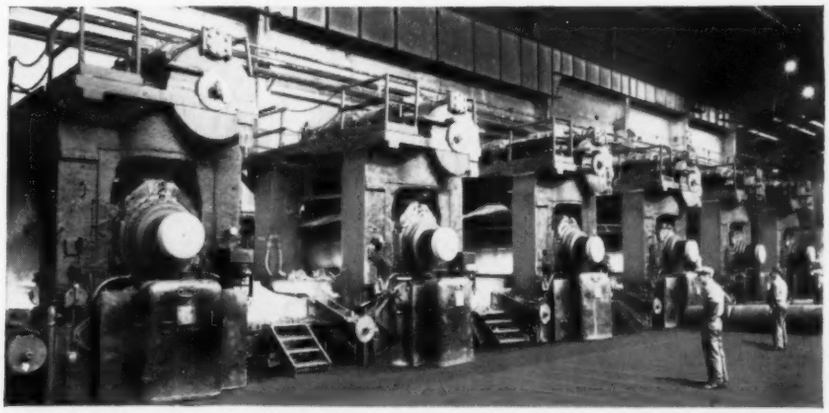
**Maintenance and downtime reduced**—long-life, solid-state semi-conductors with no moving parts are used . . . "plug-in, plug-out" replacement of faulted parts permits full production during repair.

Let General Electric's experience in steel mill control, and leadership in automating all types of process control, help you in your modernization program or in your plans for new facilities. See your General Electric sales representative. For more details on gage control, write Sect. 785-14, General Electric Co., Schenectady, N. Y.

*Industry Control Department, Salem, Virginia.*

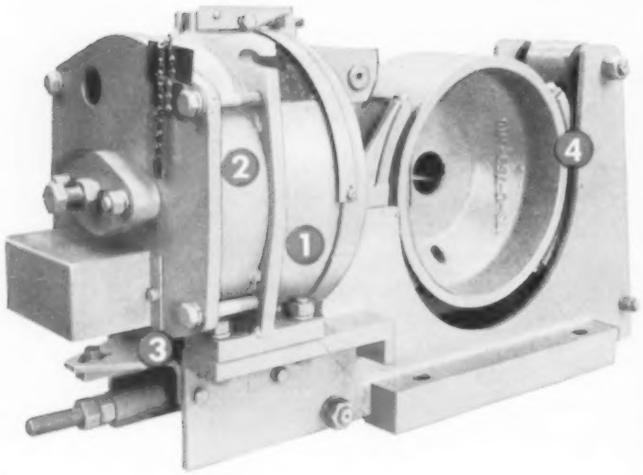
*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**



**AUTOMATIC GAGE CONTROL** for either hot-strip mills (above) or cold-strip mills is just one of many automated systems designed and built by General Electric to help you meet increasing competition.

## MILL-DUTY ACCESSORIES




### DC BRAKES

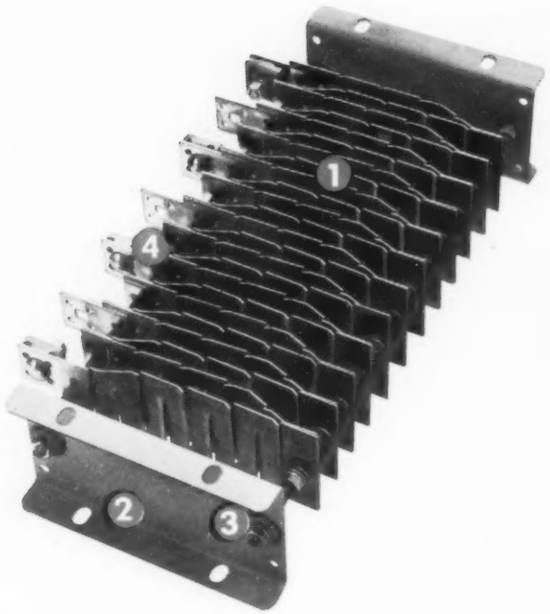
# Single-end adjustment speeds maintenance and installation

New General Electric d-c brakes—featuring single-end shoe adjustment—are designed for easy maintenance and versatile installation. And, compensation for lining wear requires simple adjustment from only one end of the brake!

Here are more new features which make General Electric d-c magnet brakes your best buy for dependable, low-maintenance service:

1. **New magnet housing design** permits vertical removal, easy interchange.
2. **New coil** features all high temp. insulating materials potted in epoxy making brake ideal for the most rugged jobs.
3. **New pivot arm** assures equal shoe braking pressure.
4. **Easy lining replacement** does not require removal of brake shoe assembly . . . just lining.

Want details? See your G-E Apparatus Sales Engineer. Or, write Sect. 784-27, General Electric Co., Schenectady, N. Y., for Bulletin GEA-7067. *Industry Control Dept., Salem, Virginia.*




### PUNCHED GRID RESISTORS

# Designed for fast, low-cost installation

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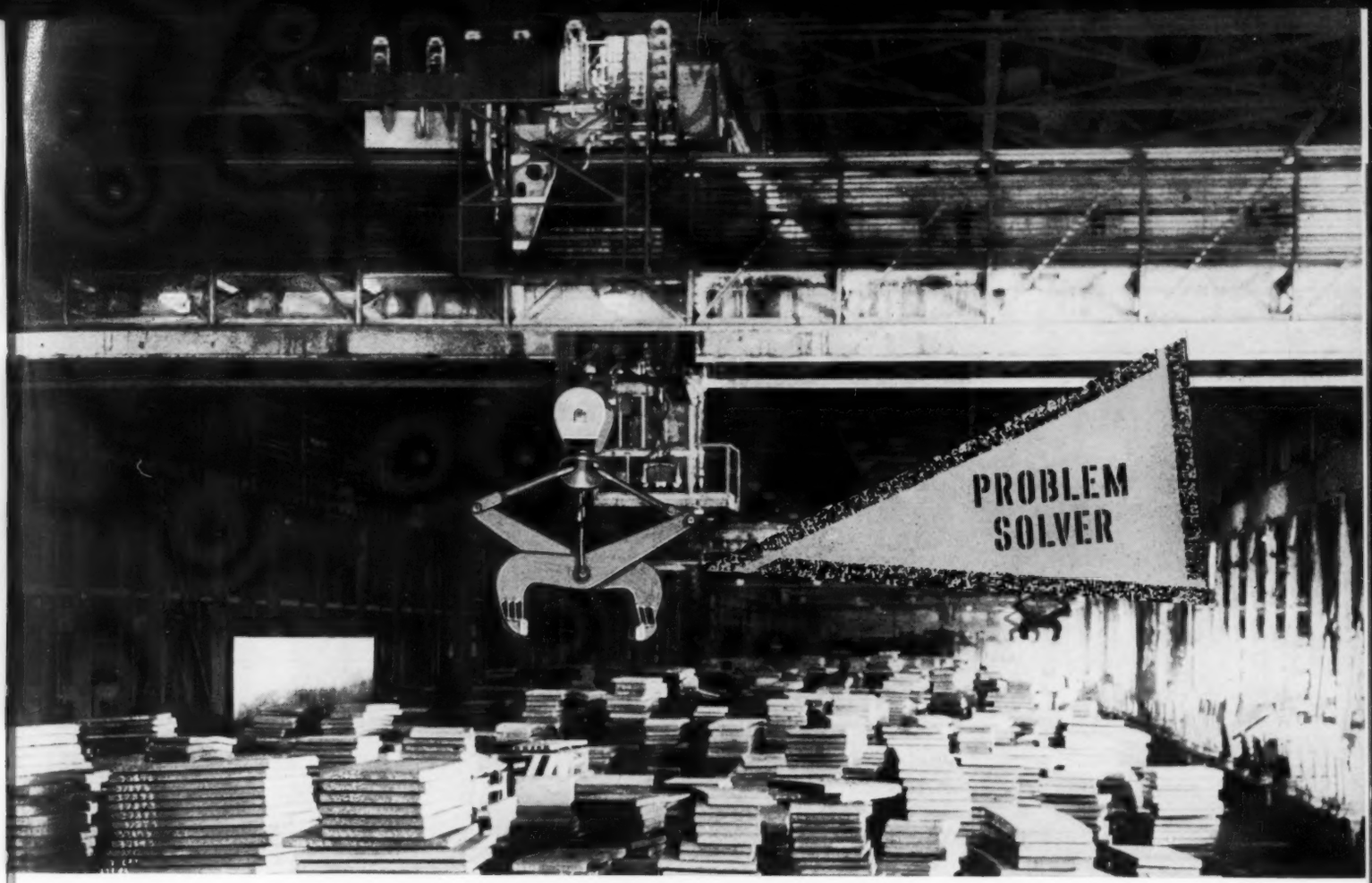
3. **Clip-lock and carriage-bolt fastener**—special device on runner guides locks box securely in frame. Front is bolted with only 2 self-holding bolts.
4. **All-purpose terminals** accommodate bus or cables. Taps provide means for adjusting resistance values.

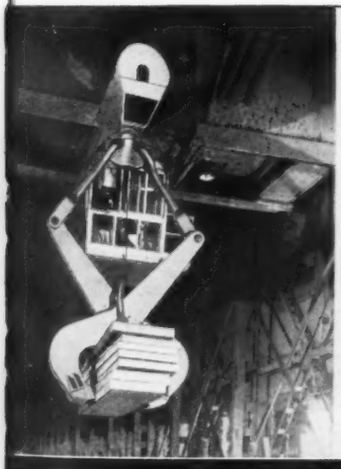
Like to know more? Contact your G-E Apparatus Sales Engineer, or write Sect. 784-27, General Electric Co., Schenectady, N. Y., for GEA-6858. *Industry Control Dept., Salem, Va.*

*Progress Is Our Most Important Product*

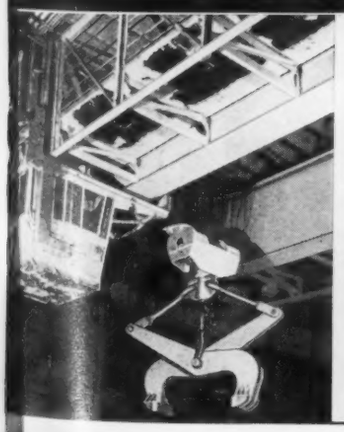
GENERAL ELECTRIC




# TONGS put a tight grip on safety and economy



The tong jaws open to 76½ inches. They are operated by a separate hoisting unit with cable connected to the pivot point of the tongs.



The cab on these cranes is air-conditioned for operator comfort. It is supported from and travels with the trolley overhanging the rear girder.

Inland Steel Company gave up chains, spacers, and "hooker" manpower in piling slabs in No. 2 Slab Yard at East Chicago, Ind. Time proved the method unsafe for both "hooker" and crane, and inefficient as well. The chains often hung-up and had to be pulled free by the crane operator. Haphazard piling also robbed the yard of storage space.

Inland Steel's plant engineers and Shaw-Box engineers solved the problem. Now five "Shaw-Box" Cranes with unique tongs handle an average of 60,000 tons of slabs a week. They are 120-foot span cranes with 50 and 25 ton hooks, each with a lifting speed of 40 FPM. All slab piling is handled from the cab which travels with the trolley. Slabs are piled far neater than before, and many more can be stored in the same area.

Since their erection in 1957, all five cranes have proved their quality in dependable service. The same creative engineering has made great problem solvers of all types of Shaw-Box Cranes, whether built to AISE specs or individual standards of construction and performance. We welcome the opportunity to serve you.

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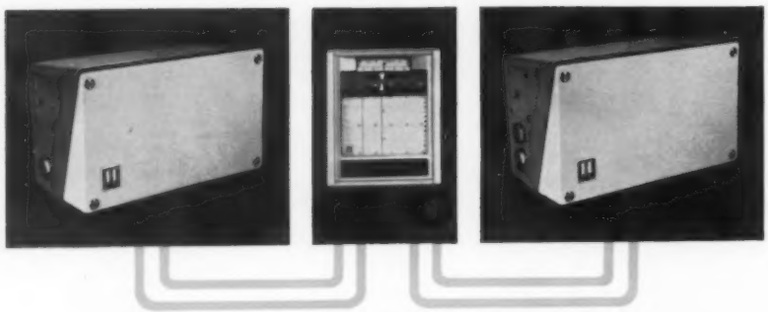
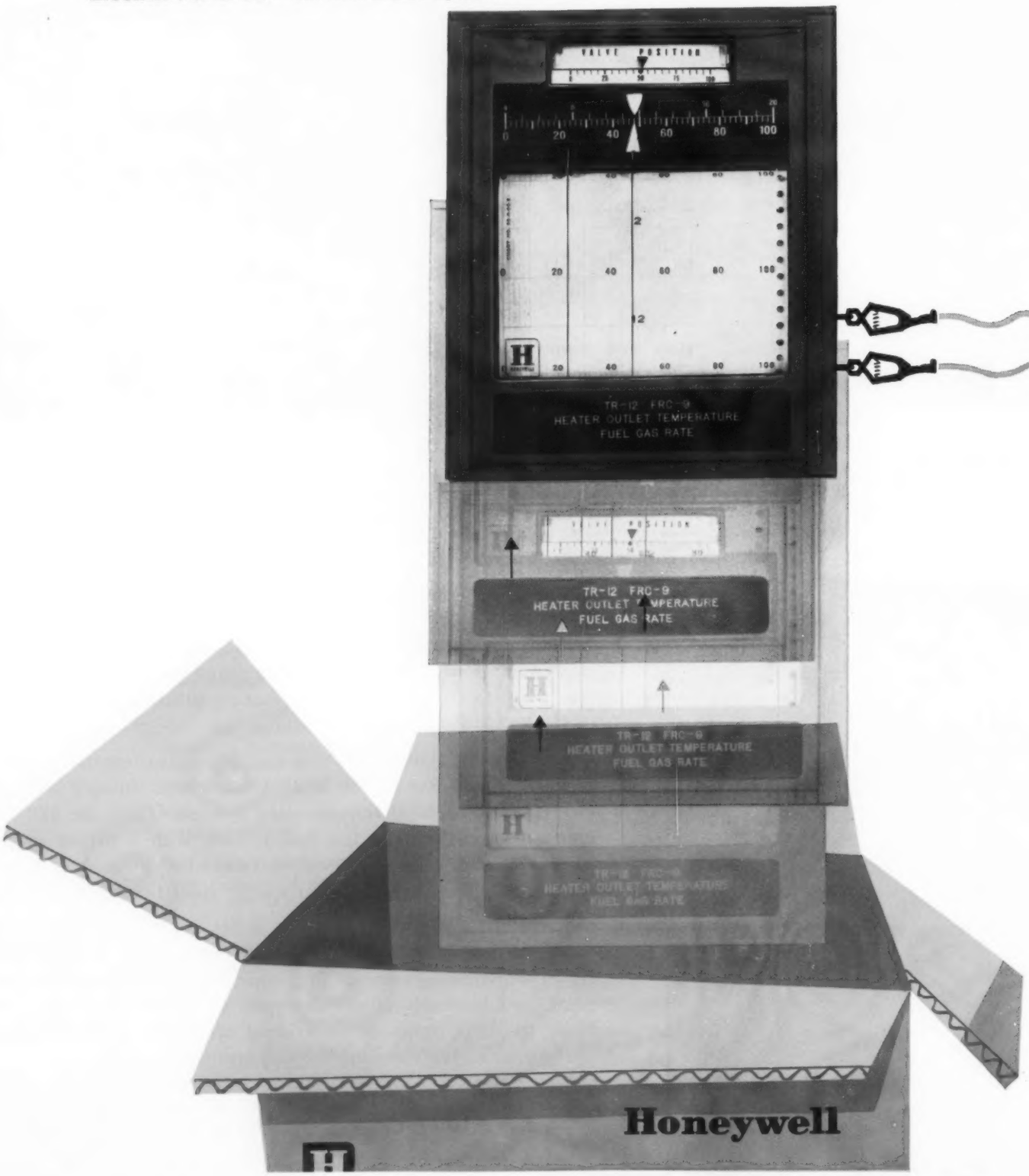


***ElectriK Tel-O-Set*—the true 2-wire system**



This "Loop Snooper" adds to the extraordinary ease of installation and maintenance you'll find in the *ElectriK Tel-O-Set* System. It's a portable test instrument that can accurately check . . . from the control panel . . . any *Tel-O-Set* unit in the field, to make sure signals are being received and sent exactly as they should be. Or it can operate and check a recorder chassis, indicator chassis or controller on the bench, with local power. The "Loop Snooper" removes trial and error from installation and maintenance.

# SIMPLEST TO INSTALL, ADJUST AND MAINTAIN

The *ElectriK Tel-O-Set* System has many features that save time in getting on stream, and keep maintenance to a minimum. For example, all process connections are isolated from the inside of *Tel-O-Set* transmitter and transducer cases, so that you can mount, pipe and wire the instruments without removing their covers. Instrument chassis can be removed for servicing without breaking any external process or electrical connections. Standardized parts and extensive use of quick-connect and plug-in design cut downtime and spare parts requirements.

No external power is required at any field-mounted *Tel-O-Set* instrument; line power is connected only at the receiver. Two-wire d-c transmission eliminates shielding and further reduces installation costs. The 4-20 milliamp signal range gives a *live* zero through the use of readily available reliable transistors.

Your nearby Honeywell field engineer can tell you how *ElectriK Tel-O-Set* advantages relate to your particular control requirements. Call him today . . . he's as near as your phone. Or write to MINNEAPOLIS-HONEYWELL, 21 Penn Street, Fall River, Massachusetts.

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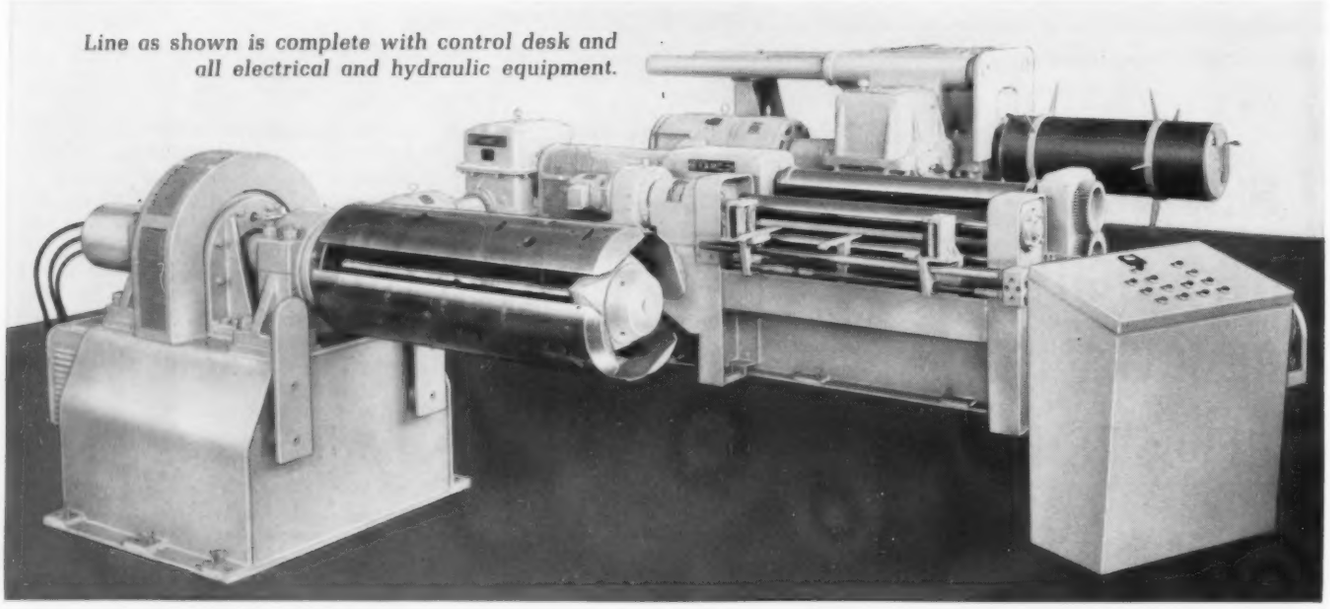

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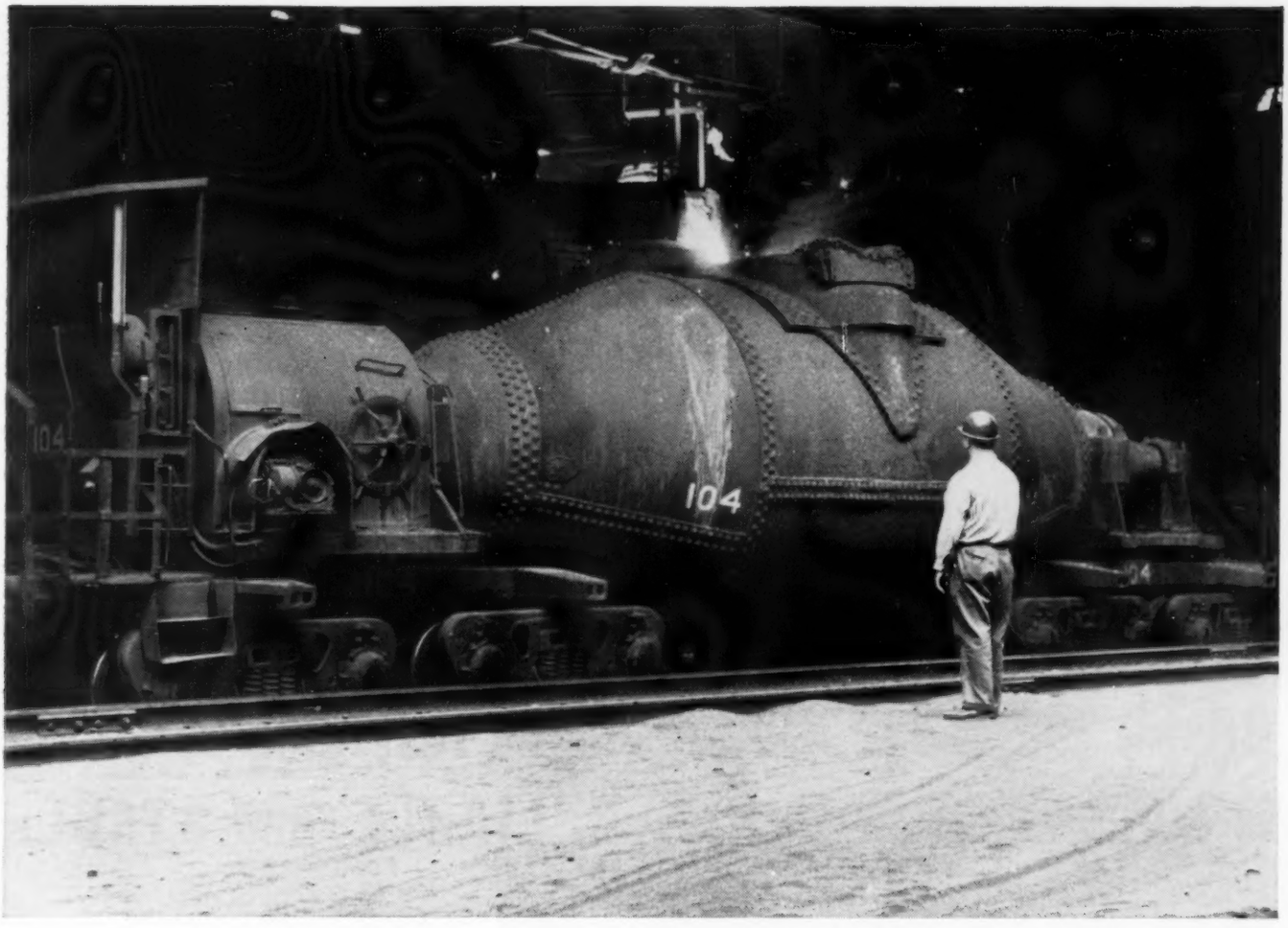


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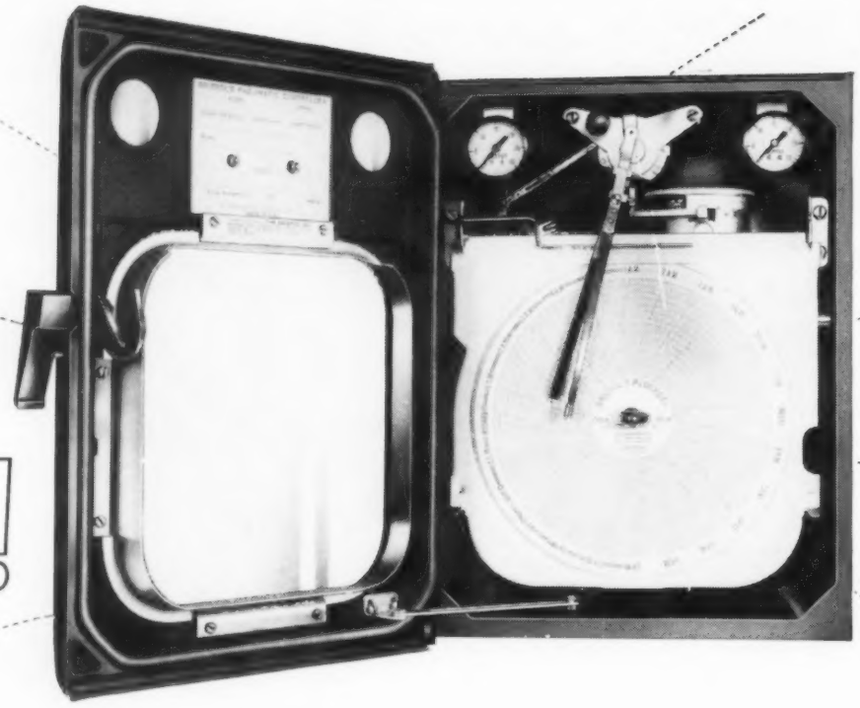

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**CONTROL UNIT CHARACTERISTICS:**

**PROPORTIONAL BAND:** 0-400% continuously adjustable, direct- or reverse-acting.

**RESET:** 0.1 to 100 repeats per minute.

**DERIVATIVE:** 0 to 10 minutes derivative time.

**AIR PILOT:** Non-bleed type.

**PILOT CAPACITY:** Over 3.0 scfm.

**FREQUENCY RESPONSE:** Essentially flat to 300 cycles per minute.

**TEMPERATURE STABILITY:** Less than 0.1% change in the output pressure for 90°F temperature change.

**CHART:** 8" diameter; wide variety available.

**MATERIAL:** Aluminum housing; 316 stainless steel internal parts; Ni-Span C feedback element.

**RECORDING CONTROLLERS OFFERED FOR:**

**PRESSURE AND VACUUM:** Ranges from full vacuum to 15,000 psi.

**TEMPERATURE:** Ranges from −100°F to +1000°F.

**FLOW AND DIFFERENTIAL PRESSURE:** With mercury-type manometer and dry-type differential unit.

**LIQUID LEVEL:** With bulb unit and mercury manometer and dry-type differential unit.

**HUMIDITY:** Zero to 100% relative humidity.

**Advanced Design*

**BRISTOL** ...for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

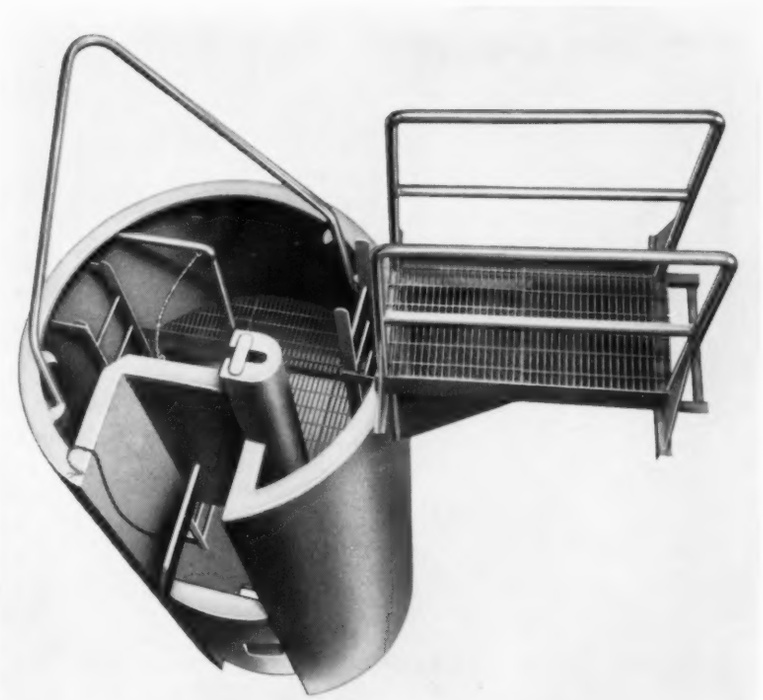
# Faster Heats?
# Fewer Ladles?
# Same Cranes?

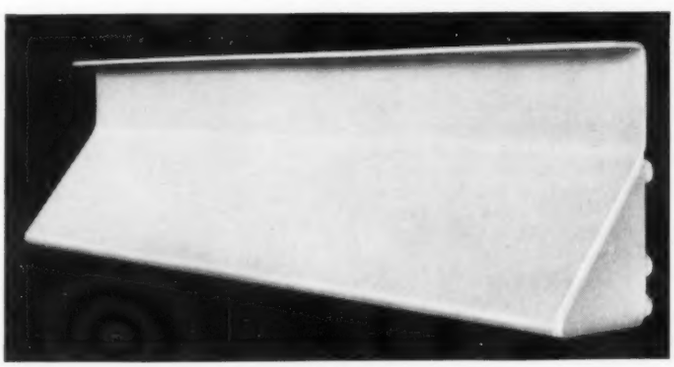
**Sure it's true . . . and it's guaranteed!**
**Ask anyone who uses this Sticker Exclusive!**

**Sticker ▶**
**Ladle Maintenance**
**"Safety Cage"**

**SAFE Stopper and Rod Setting**
**Immediately After**
**Pouring Steel**

*Patented*





*Patented*

**◀ "Seamless Face"**
**Water-Cooled Skewback Channel**
**— *Another Sticker Exclusive***

**Custom-built to fit your roof contour**
**Eliminates skew tile**
**Provides permanent skew face**

**Sticker**
**STEEL PLANT EQUIPMENT**

**STICKER INDUSTRIAL SUPPLY CORPORATION**
1991 LEE ROAD • CLEVELAND 18, OHIO

*proved*
**SPRAY NOZZLE**
*design*

***TO IMPROVE SUCH SPRAYING OPERATIONS AS***

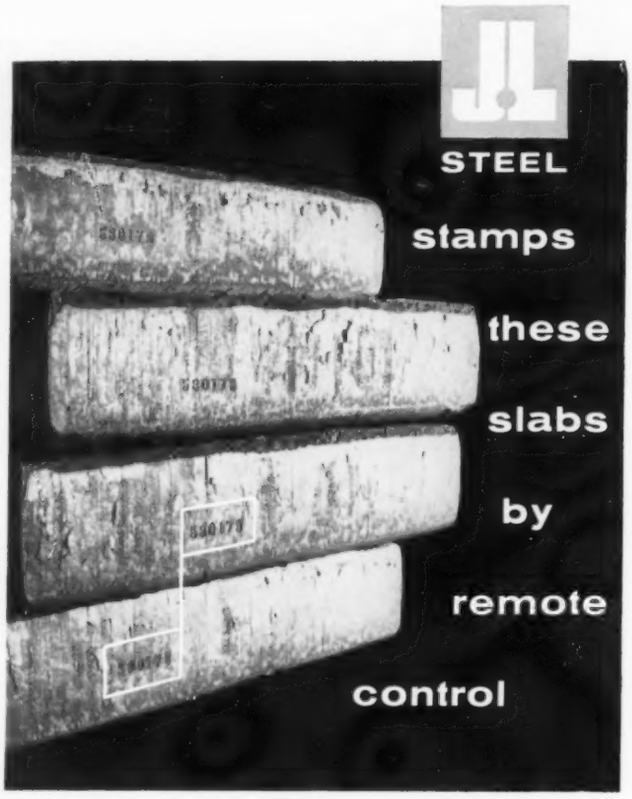
**• DESCALING • OXYGEN PROCESS GAS COOLING • PIG—INGOT MOLD—SLAB AND HOT STRIP COOLING • ROLL COOLING • COOLING OPEN HEARTH REGENERATORS • LUBRICANT SPRAYING • BLAST FURNACE GAS WASHING AND COOLING**

Whatever the application you will find Spraying Systems Spray Nozzles provide noticeable improvement in spraying operations . . . and often materially lower cost. Proved by performance. Supplied in a complete choice of types and capacities for selection of spray characteristics exactly as needed. Your inquiry is cordially invited.

**SPRAYING SYSTEMS CO.**
3262 Randolph Street • Bellwood, Illinois

For complete information write for Catalog 24 and special data sheet folder "Steel Mill Applications".

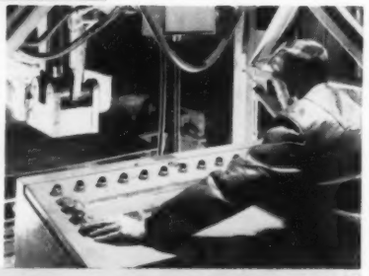





Deep, clear-cut, even impressions in slabs and blooms—*it's being done by remote control* at the 44″ Blooming Mill in Jones & Laughlin's Aliquippa Works. This machine does the job better, faster, more economically, more safely than hand methods previously used. *Write for new bulletin on Remote-Control Marking.*

**Slab in position for stamping with pneumatically-powered marking head. Both blooms and slabs are marked by the machine at J & L.**

**Any of the nine numbers in the marking head may be changed by pressing buttons on this control panel. A single button also actuates the stamping cycle.**



*Mecco* **SAFETY MARKING TOOLS**

Model 701-RCW
**SLAB MARKER**

**A Product of the Marking Device Industry**

**M. E. CUNNINGHAM CO.**
1041 CHATEAU STREET, PITTSBURGH 33, PA.

# IT'S THE *Built-in Quality* THAT COUNTS!

*Designed to fit your present resistor space*

**STEEL GRID RESISTORS**
**consistently prove their value in**
**STEEL MILL SERVICE**

**P-G has BOTH!**

**STANDARD** Resistors

**WELDED** Resistors

*Write for Bulletins*

By use of those durable raw materials . . . steel and mica, and the P-G exclusive features of design, these Steel Grid Resistors have the "built-in quality" to overcome factors which often cause resistor failures. Vibration, moisture laden or corrosive atmospheres have little effect on continuity of service. Try Post-Glover Resistors for heavy duty applications where resistors are subject to severe service . . . continuous "Trouble-Free" performance is assured.

*The Nonbreakable Steel Grid Resistor*

P-G

ESTABLISHED 1892

THE **POST-GLOVER** ELECTRIC COMPANY

OFFICE and FACTORY—Kenton Lands Road, Erlanger, Kentucky

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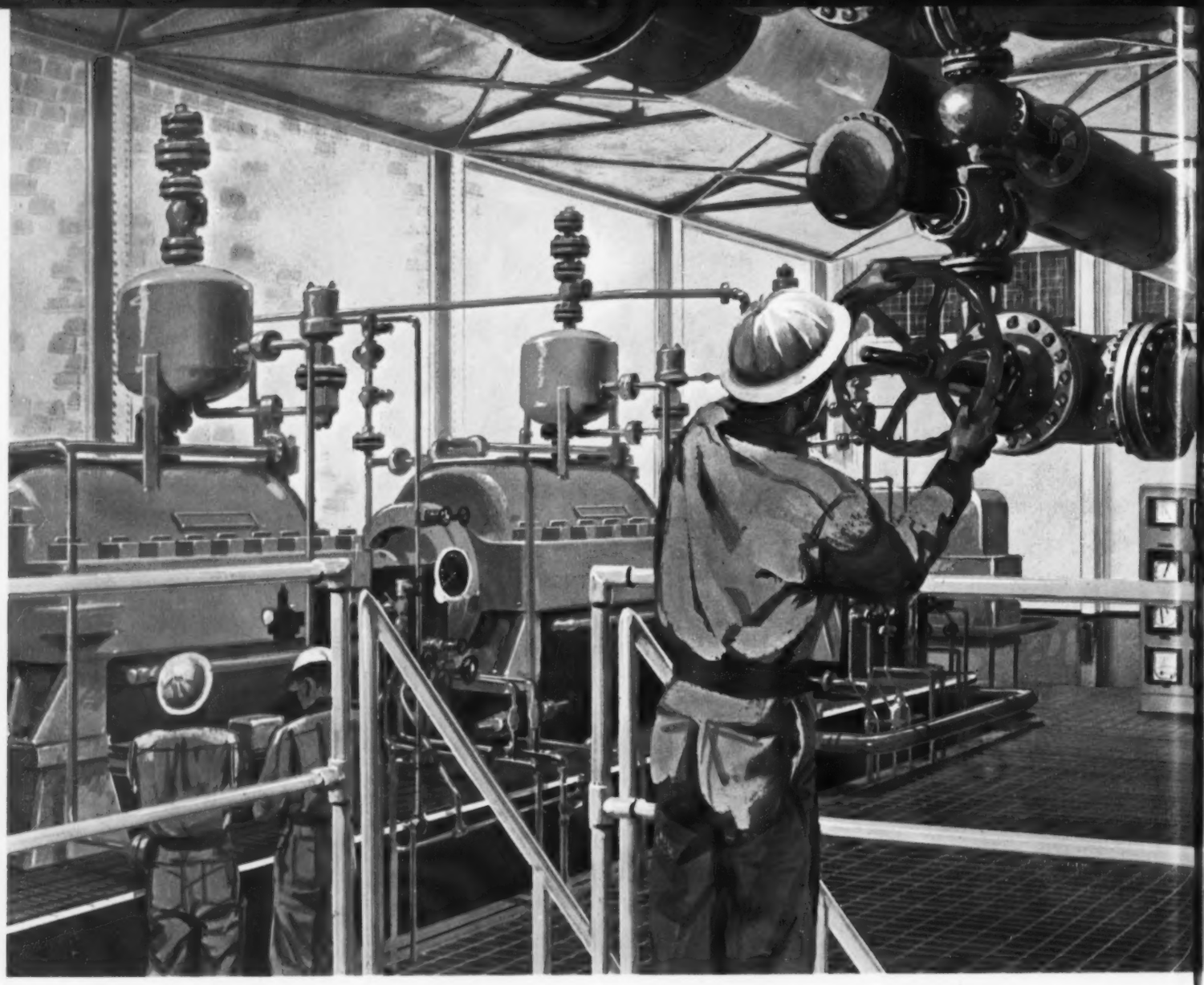
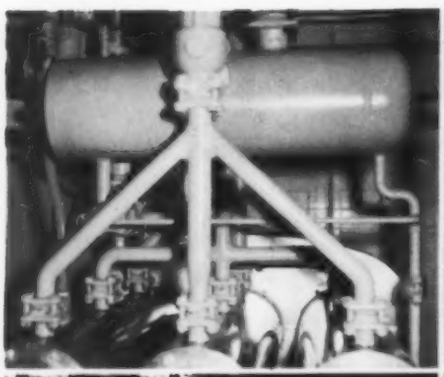
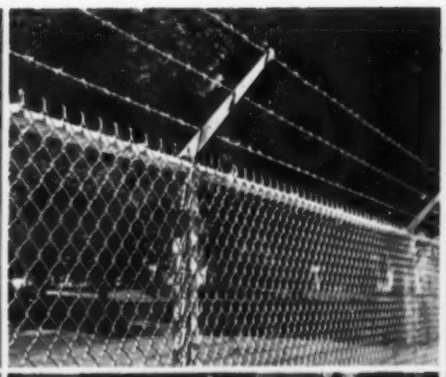
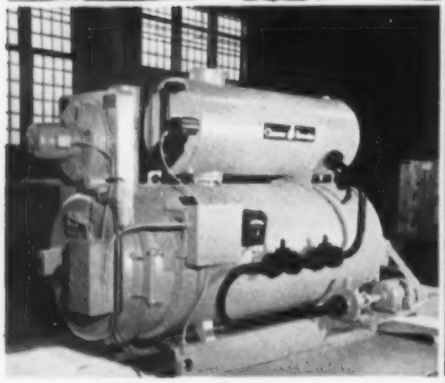
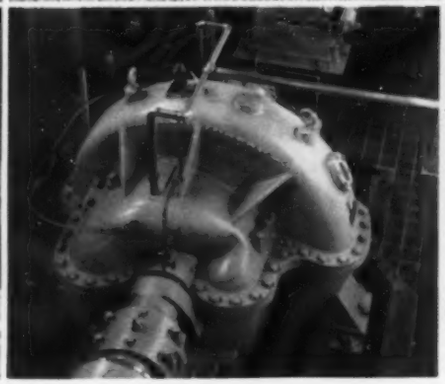
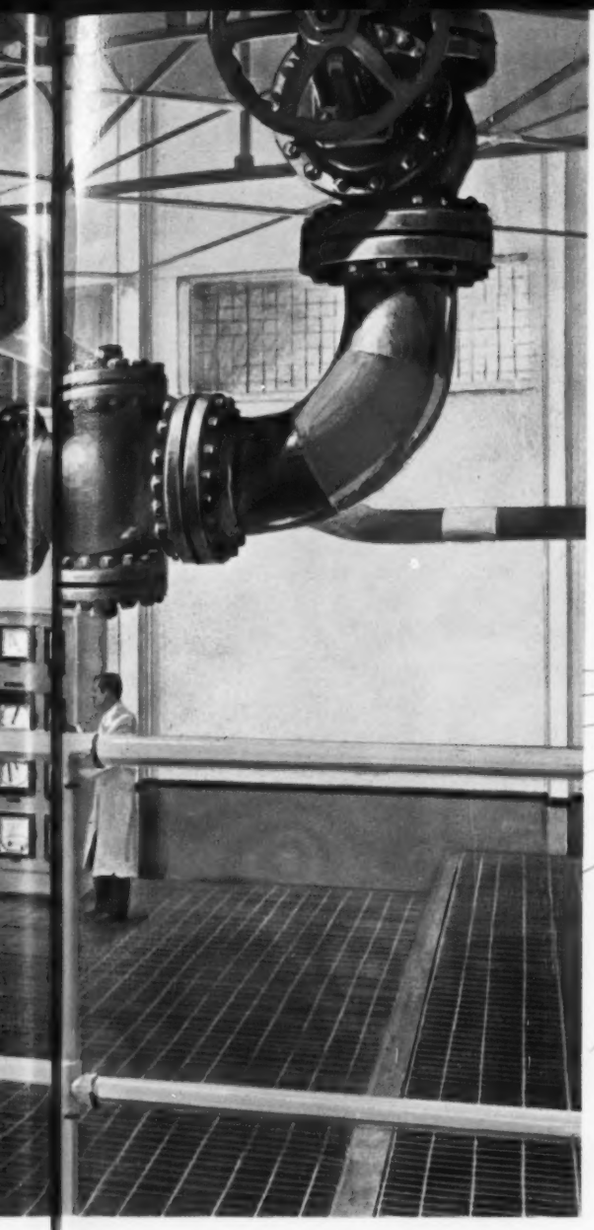












## Rust-Oleum

# NEW COLOR HORIZONS

## System

HERE is a modern, functional *system* that combines four important points. (1) the ability to stop rust, (2) modern color harmony, (3) durability to last and last, (4) ease of application. From machinery, equipment, and structural steel to tanks, steel fences and metal sash – the Rust-Oleum New Color Horizons System can provide lasting beauty in the colors of your choice. Ask your Rust-Oleum Industrial Distributor, together with your Rust-Oleum Factory Specialist, to make a survey of your plant and provide complete recommendations. Rust-Oleum Industrial Distributors maintain complete stocks for prompt delivery in all principal cities of the United States, Canada, and in many countries around the world.

Rust-Oleum, in its various forms, can also save you time and money on problems like these: Heat Resistance, Water Resistance, Chemical Resistance, Coating Galvanized Metal, Speedy-Dry Coatings (less than thirty minutes to dry).

PROVED THROUGHOUT INDUSTRY FOR OVER THIRTY-FIVE YEARS

# RUST-OLEUM®

See our catalog in Sweet's.

**STOP RUST by applying Rust-Oleum 769 Damp-Proof Red Primer directly over the sound rusted surface**

Save time, money, and metal. Brush Rust-Oleum 769 Damp-Proof Red Primer right over the remaining sound rusted surface after scraping and wirebrushing to remove rust scale and loose rust. **Specially-processed** fish oil vehicle penetrates rust to bare metal as proved in radioactive tracing studies.

STOPS RUST!®

Distinctive as your own fingerprint. There are imitations, but only one Rust-Oleum.

Insist upon industry-proved Rust-Oleum. Accept no substitute.

*You take the brush! Try a free test sample!*

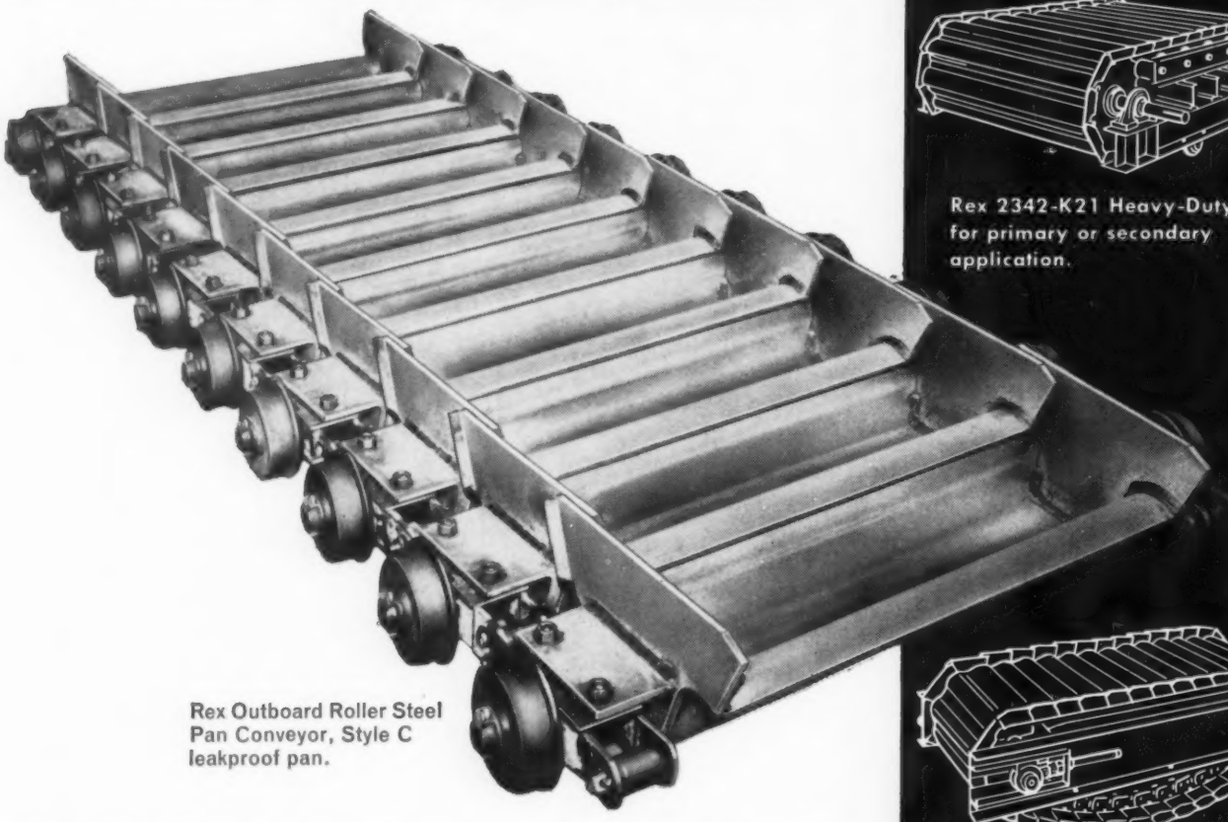
ATTACH TO YOUR LETTERHEAD

**RUST-OLEUM CORPORATION**
**2985 Oakton Street • Evanston, Illinois**

At no cost or obligation, please send me:

- ☐ New full-color catalog on New Color Horizons System and specialized Rust-Oleum systems, including color charts and applications.
- ☐ FREE TEST SAMPLE of Rust-Oleum 769 Damp-Proof Red Primer.
- ☐ Please have your representative contact us to discuss a plant survey.

# How to convey hot bulk materials with initial temperatures up to 1900°



Rex Outboard Roller Steel Pan Conveyor, Style C leakproof pan.

Rex Outboard Roller Steel Pan Conveyors provide a practical solution to many unusual conveyor problems.

Here are two of the ways improved Rex design gets right to the heart of the heat problem:

1. Chain and rollers are isolated from maximum temperature heat zone.
2. Carbon steel pans, with large pan surfaces, provide maximum heat transfer.

**Long wear life, easy maintenance**—Ruggedly built for extra stamina, Rex Outboard Roller Steel Pan Conveyors are known for their long, trouble-free service and low maintenance cost. Wear is confined to heavy outboard rollers; square through rods connecting the chains assure rigidity, equal load distribution; and outboard roller design permits easy servicing *without* disassembly of chain or conveyor.

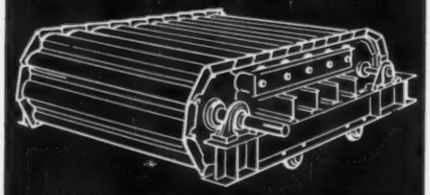
**Preferred throughout industry**—Deep pan construction, shown above, is ideally suited for use in a wide range of heat processing applications; for example: calcining, sintering, briquetting, beneficiating and nodulizing. This style is available in a wide range of sizes.

**Other types available for every service**—For information on how Rex Apron Feeders, Apron and Pan Conveyors can help you cut production costs, write CHAIN Belt Company, 4693 W. Greenfield Ave., Milwaukee 1, Wis. In Canada: REX Chainbelt (Canada) Ltd., Toronto and Montreal.

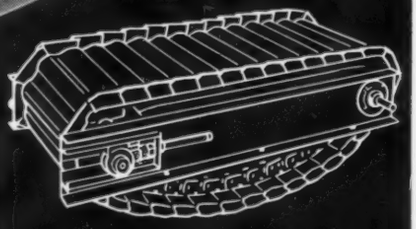
REX®

OUTBOARD ROLLER STEEL PAN CONVEYOR

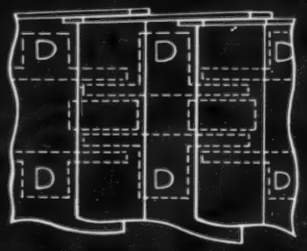
## Types For EVERY Service

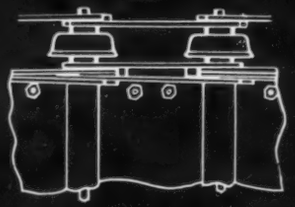


Rex 2342-K21 Heavy-Duty Feeder for primary or secondary application.

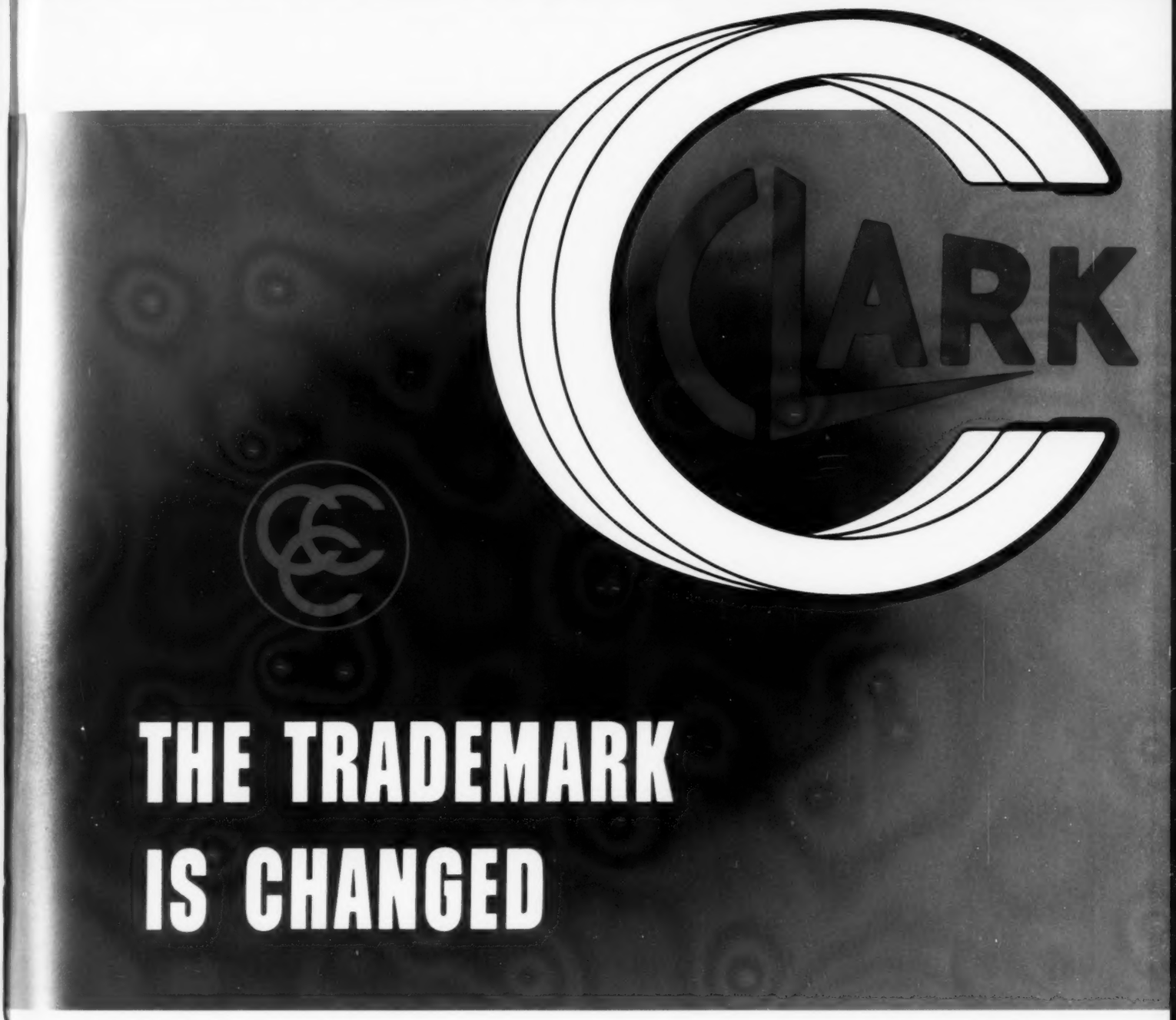


Rex 531-K17 Light-Duty Apron Feeder, used under hoppers and bins to regulate material flow.





Style A aprons with Type K or A chain attachments furnished as machinery parts for many applications.



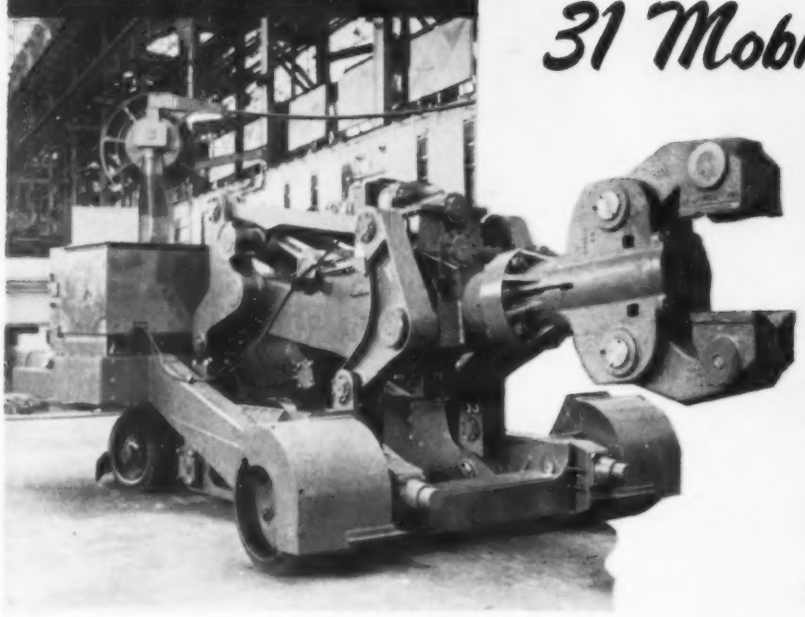

# THE TRADEMARK IS CHANGED

## ...to match the high performance standards of the nation's top-quality electrical control equipment

Soon you will see this new trademark on Clark control devices and systems. Behind this symbol are the precise engineering and exacting production methods which make possible the high standards of quality for which Clark is famed. Behind it are men with the know-how to create the longest lived, sturdiest, most efficient electrical controls. Behind it are answers to your needs for everything from standard equipment such as motor starters, relays and push buttons to complete engineered systems.

For help in solving your control problems, contact your local Clark distributor or district sales office, or write direct. *The Clark Controller Company* • Main Plant: Cleveland 10, O.—Western Plant: Los Angeles 58, California—In Canada: Canadian Controllers, Limited, Toronto, Ont.

## Another Wellman Record



# 31 Mobile Manipulators and Furnace Chargers ranging from 15cwt to 8ton capacity

**now being manufactured at our Works for leading companies in Britain, France, Germany, Sweden, Yugoslavia, Czechoslovakia, India and Japan.**

**This remarkable achievement reflects the highly efficient operation of Wellman Mobile Machines and it is note-worthy that in numerous cases orders for additional units have been received.**

**Standard models, of different types and a wide range of capacities, meet most of the varying conditions encountered in the ferrous and non-ferrous industries.**

**Suitable adaptations of standard models or new designs can be provided to accommodate special working conditions.**

**Our "Mobile Machines" brochure will be sent gladly, on request.**

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION LTD
PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1 WORKS: DARLASTON, South Staffs, & BELFAST

**FINEST CARBON and ALLOY STEEL CASTINGS**

# *by Farrell-Cheek*

## A HUGE LINE

*Hardly a phase of American metal working and engineering is without the use or need of these products.*

**WRITE FOR THE CATALOGS YOU NEED!**

*Finest Name in Cast Steel!*

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- CATALOG NO. 22 — WIRE ROPE FITTINGS AND ACCESSORIES
- CATALOG NO. 23 — CONVEYING NEEDS
- CATALOG NO. 24 — WHEELS AND ROLLERS
- SPECIFICATIONS

**We vouch for the design and production quality of our castings . . . and we vouch for the benefit they can be to your operation. However, you must become acquainted with F-C castings to best know how they can serve you.**

*PLEASE ALLOW US TO SEND YOU THOSE CATALOGS WHICH ARE OF PARTICULAR INTEREST. YOUR INQUIRY WILL BE GIVEN IMMEDIATE ATTENTION.*

**"FOUNDRYMEN FOR OVER FIFTY YEARS"**

**FARRELL-CHEEK STEEL COMPANY**

*108 LANE STREET, SANDUSKY, OHIO*

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# THOUSANDS OF CUTS THROUGH STEEL RODS WITHOUT A BREAKDOWN!

Typical of the reports that come from rod and wire mills everywhere. Proof-positive that Porter has practically eliminated down-time for repairs. To cut maintenance costs and speed your cutting operations, it will pay you to get all the facts on the Porter one-hose HYDRAULIC ROD and BAR CUTTERS.

***CUTTER BLADES THAT ARE REALLY RUGGED***

Blades are longer . . . have *more* bearing surfaces for rigid alignment. No side thrust to cause breakage. Filtered air taken into the cylinder is forced out around the movable blade on each cut — eliminates danger of dirt reaching bearing surfaces causing oil leakage and wear.

***FOOL-PROOF HYDRAULIC SYSTEM***

Just-one-hose design cuts replacement costs in half. Finger-tip control of cutting action! Reservoir-type 40 micron oil filter is easy to change. Adjustable relief valve saves wear and tear by providing the correct pressure for any cutting job. 12-Volt control circuit provides for operator safety.

**PORTER**

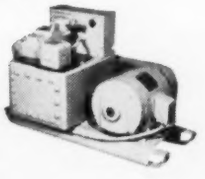
**HKP®**

***ONE HOSE HYDRAULIC***

**ROD & BAR CUTTER**

***WRITE TODAY FOR ALL THE FACTS***

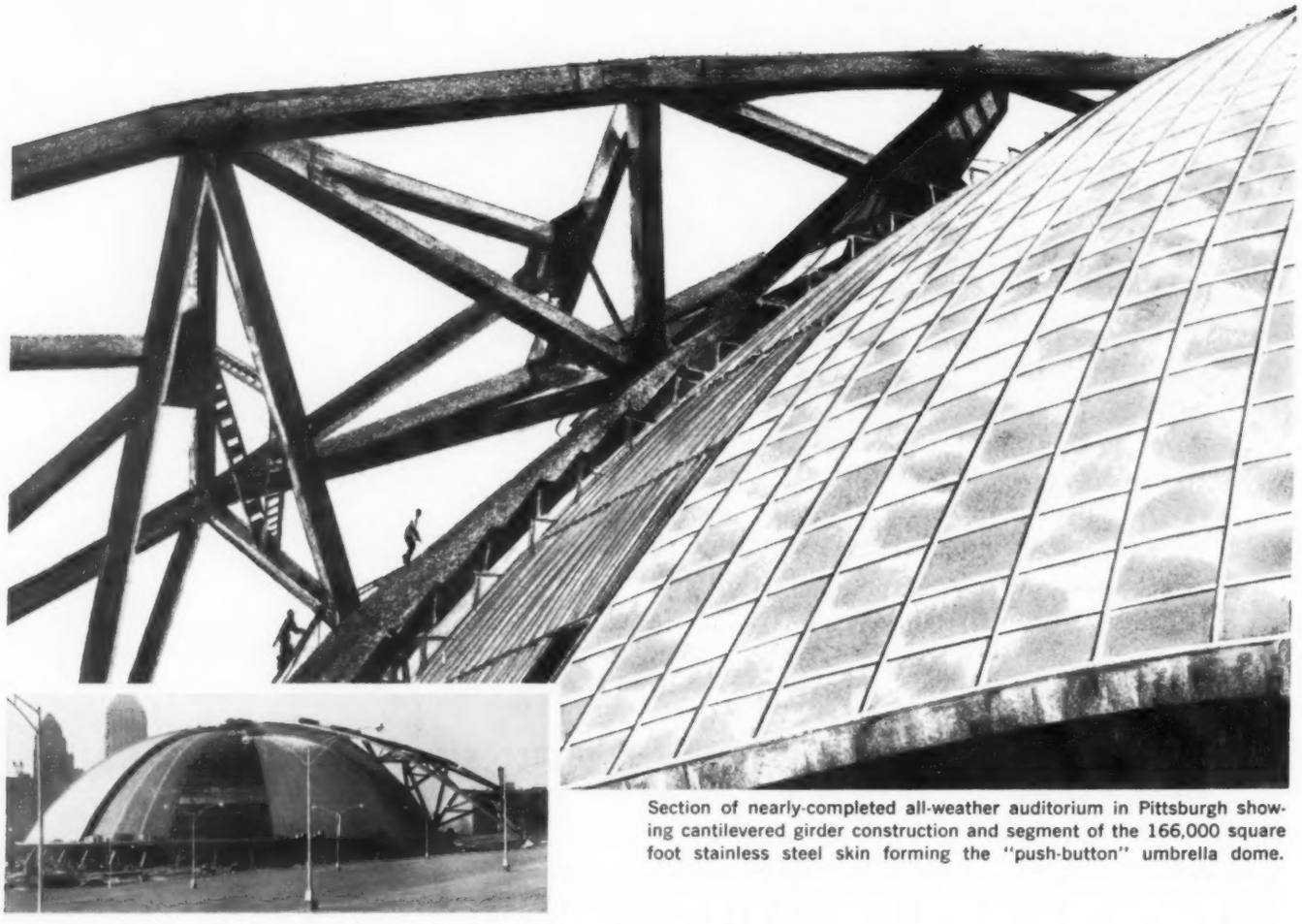
Let us show you how any combination of 3 cutter-heads for capacities up to 1⅜" steel rods and 5 hydraulic power units can be matched to your exact requirements. Or we can design special heads for punching, crimping, heading, or forming. Write today for an on-the-job demonstration or a copy of our Rod and Bar Cutter Catalog.



**H.K. PORTER, INC.,**

***Somerville 43, Mass.***

# when you're producing Electric Steels



Section of nearly-completed all-weather auditorium in Pittsburgh showing cantilevered girder construction and segment of the 166,000 square foot stainless steel skin forming the "push-button" umbrella dome.

## GLC Electrodes will give you these extra values

When you specify GLC electrodes you get a product
of **superior quality, plus** such extra values as...
**unceasing research** that leads to steady product improvement...
**substantial inventories** maintained for your convenience...
**fast shipment** and delivery...
and **technical service** for customers
that is remarkably prompt and competent.
These extra values are important as they provide
a substantial share in the reduction of melt-ton costs.

PRODUCTS ELECTRODE GLC DIVISION YOU CAN TRUST®

**GREAT LAKES CARBON CORPORATION**

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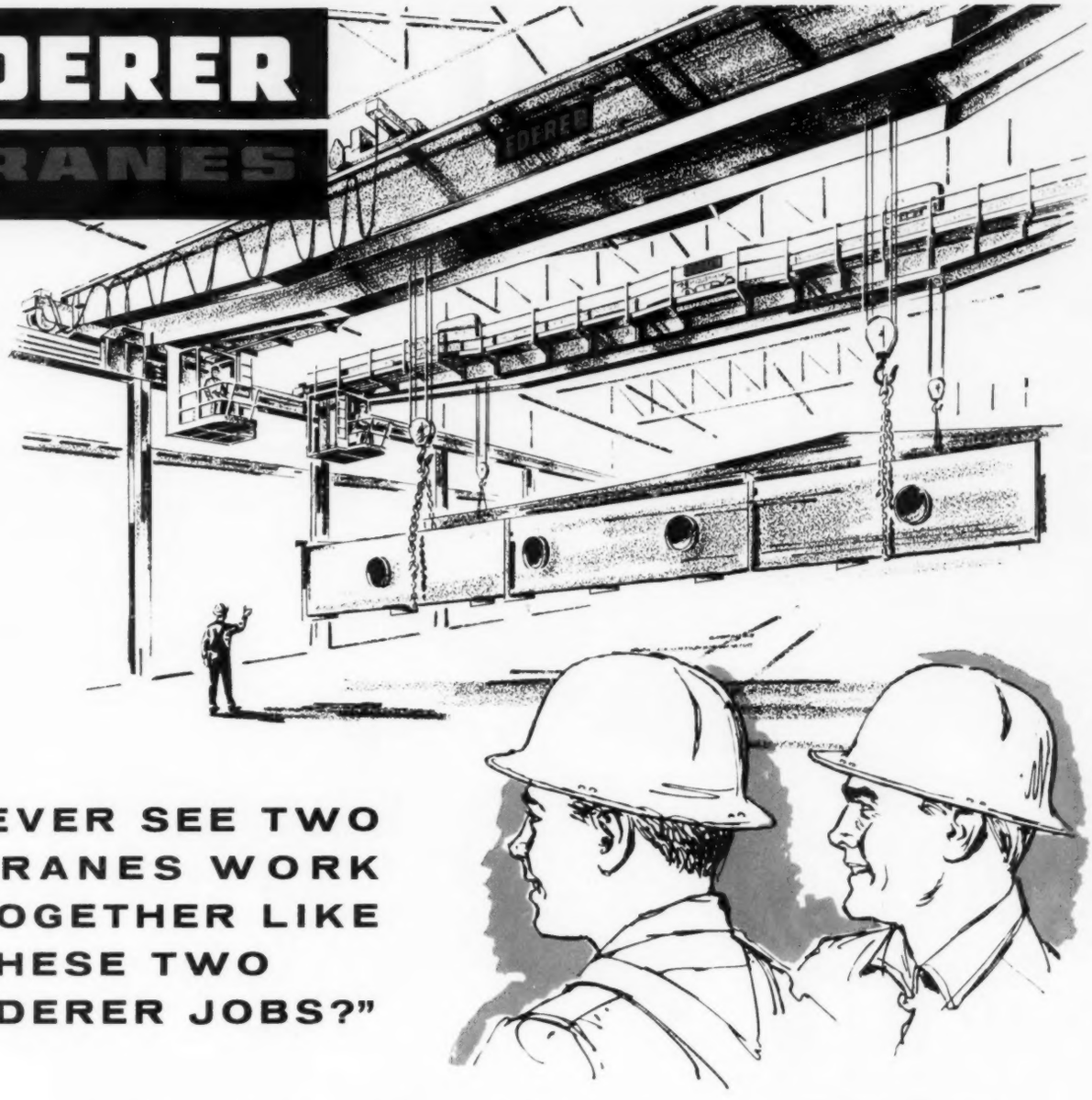
# EDERER CRANES




## "EVER SEE TWO CRANES WORK TOGETHER LIKE THESE TWO EDERER JOBS?"



**In many industrial plants it takes two cranes to handle extra heavy or extra large loads. This means working in "tandem" . . . calls for synchronized speeds, coordinated operation. EDERER'S "job-engineered" full magnetic crane controls give operators exactly the "delicate touch" that enables them to work two cranes together in this fashion.**

**This is only one phase of the "job-engineering" that has put EDERER cranes to work in all phases of the metals industries—mills . . . warehouses . . . fabricating plants . . . foundries . . . forge shops . . . machine shops. Whatever the materials handling requirements in your particular plant, EDERER can "job-engineer" a crane to your exact needs. Why not talk to an EDERER engineer about it?**

365C61

*EDERER industrial crane catalog . . . Bulletin CR-610 . . . gladly sent to you on request.*

EDERER

**ENGINEERING COMPANY**

**2935 FIRST AVENUE SOUTH • SEATTLE 4, WASHINGTON**

**EXPORT DIVISION:** 301 Clay St., San Francisco 11, California

*SINCE 1901 "JOB-ENGINEERING" CRANES AND HEAVY EQUIPMENT*

# TRANTINYL

## GUIDES THE STEEL INDUSTRY

## Mill Guides

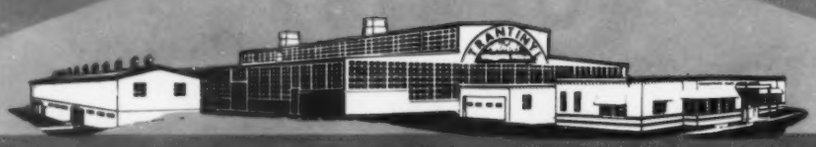
used by J&L STEEL

in 44" strip mill
at Aliquippa Works

*"TRANTINYL" Service to Leading Steel Companies ... continuous for a quarter-century*

**Youngstown Alloy Casting Corporation**
**Youngstown, Ohio**

Guides for Rolling Mills • Tube Mills • Straightening Machine Guides




G-15

Sole Licensee to cast "TRANTINYL" for the Midwest, West and South: WAUNAKEE ALLOY CASTING CORP., Waunakee, Wis.

NEW

# SOAKING PITS...

## ...START A LONG LIFE with Ramtite®

*Looking into one of the four soaking pits showing all RAMTITE products*

*Visitors' eye view of a RAMTITE Cover for one of the four new soaking pits*

A large Eastern steel mill recently installed RAMTITE products in four soaking pits as a part of their new overall soaking pit program. A complete SPECIAL SUPER RAMTITE No. 25 anchored construction was installed in all covers, copings, walls and cored division walls. The slag lines of all walls in the four pits were of anchored 90-RAM high alumina plastic construction.

Have you refractory needs now which RAMTITE products could satisfy — or refractory problems which they may solve?

**"There's a RAMTITE® Product for Every Refractory User."**

**The Ramtite Co.**
DIV. OF THE S. OBERMAYER CO.
1813 S. Rockwell St., Chicago 8, Ill.

**THE RAMTITE CO., Div. of the S. Obermayer Co.**
1813 S. Rockwell St., Chicago 8, Ill.

*Please send:*

- ☐ Information on use of RAMTITE in Soaking Pits
- ☐ Your new folder on Open Hearth Furnaces
- ☐ General Information about RAMTITE Products
- ☐ Representative (without obligation)

Company Name_____

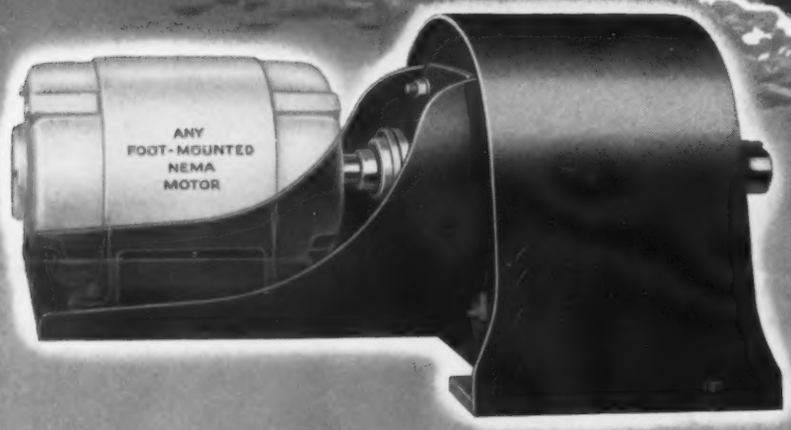
Attn. Mr._____ Title_____

Address_____

City_____ Zone____ State_____

# FALK

## A GOOD NAME IN INDUSTRY




**20,000 hp at 100 rpm**

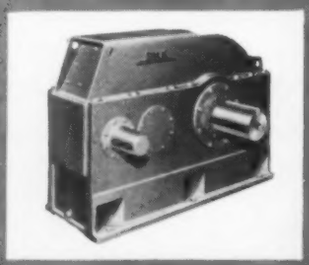
**...or 75 hp at 100 rpm**

**THE FALK *ALL-STEEL*, ALL-MOTOR MOTOREDUCER**
**(also available in integral models)**
**...one of America's First Family of Power Transmission Products**

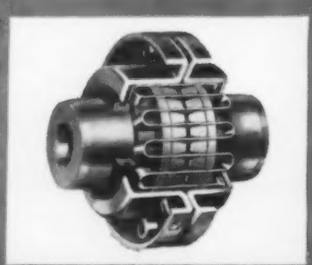
*Other Members:*

**SHAFT MOUNTED DRIVES**
—up to 125 hp. Ask for Bulletin 7100. Also Flange Mounted and Screw Conveyor Drives.

**SPEED REDUCERS**
Parallel Shaft up to 3500 hp. Ask for Bulletin 1100. Also Right Angle and Concentric Shaft designs.



**STEELFLEX COUPLINGS**
All-steel, torsionally resilient. 34 sizes, from .3 to 130,000 hp at 100 rpm. Ask for Bulletin 4100.



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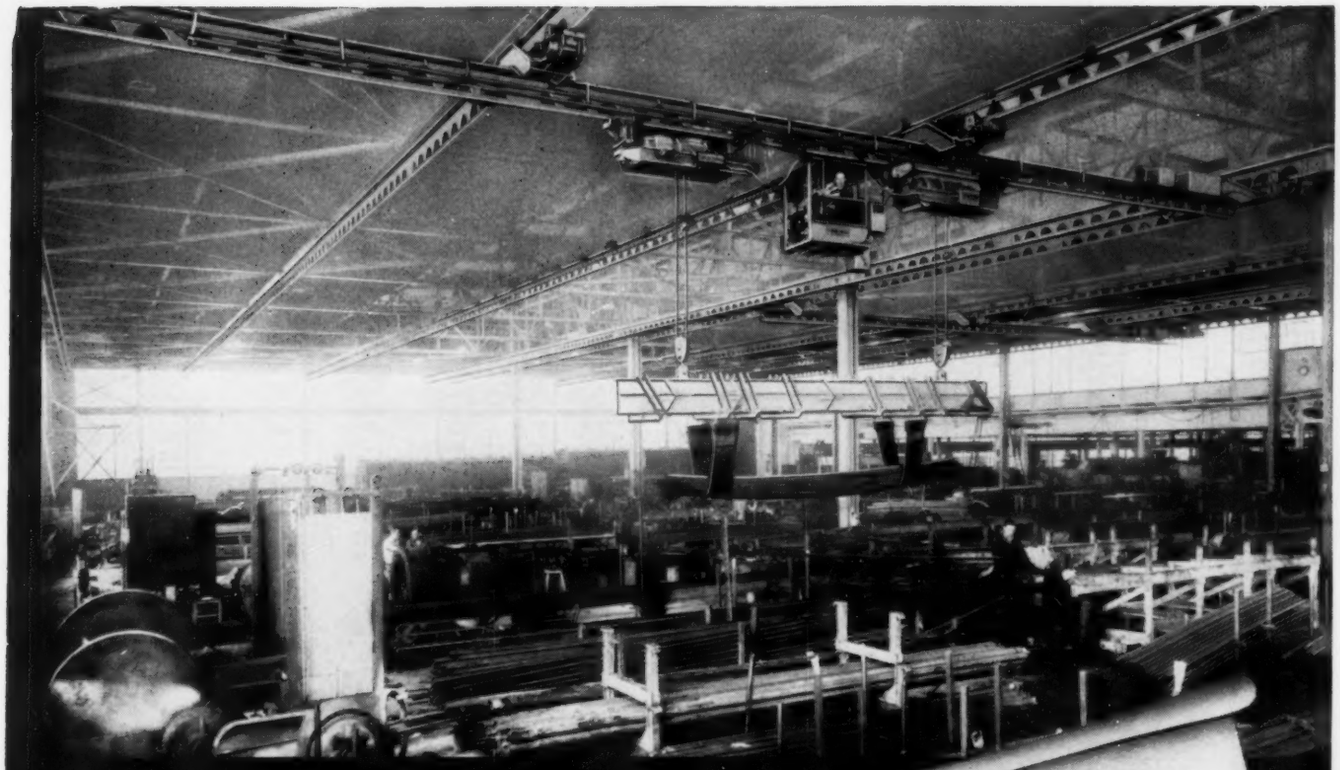

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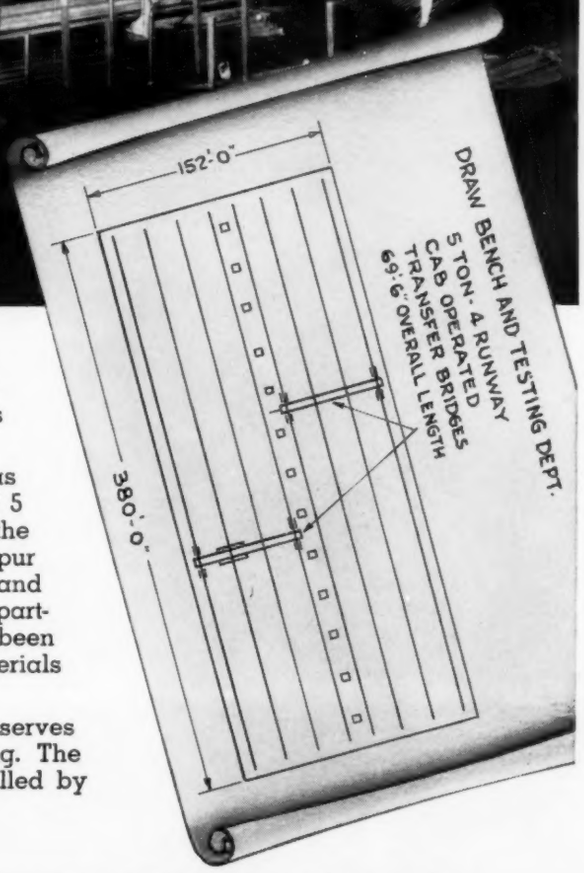


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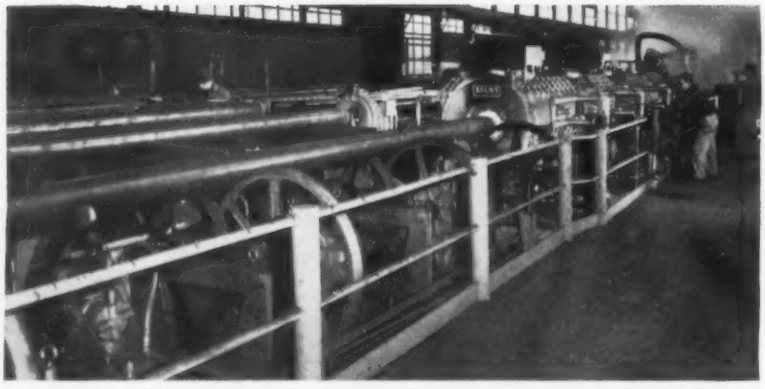

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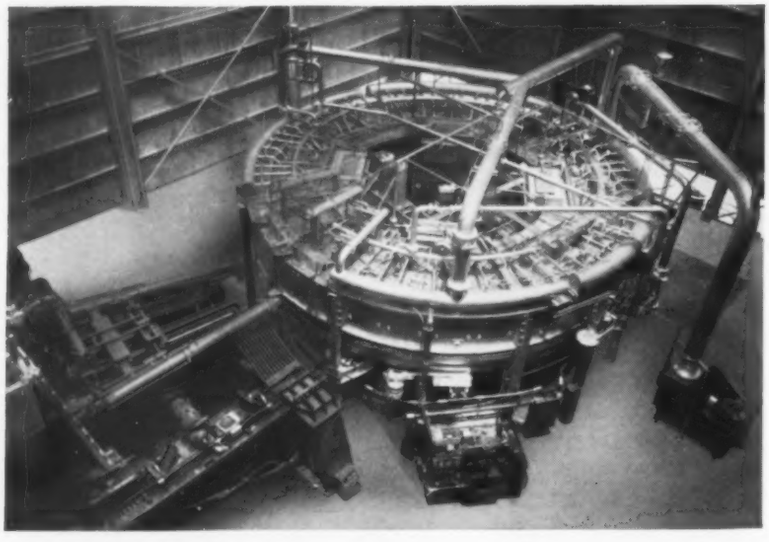

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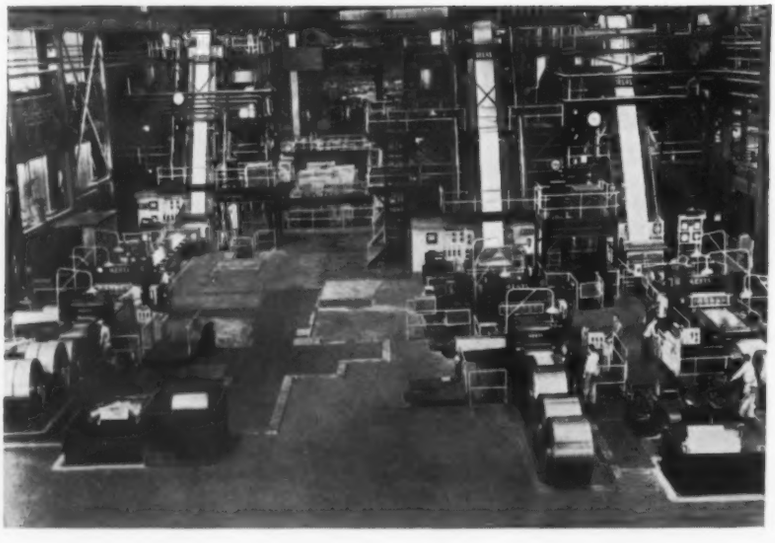

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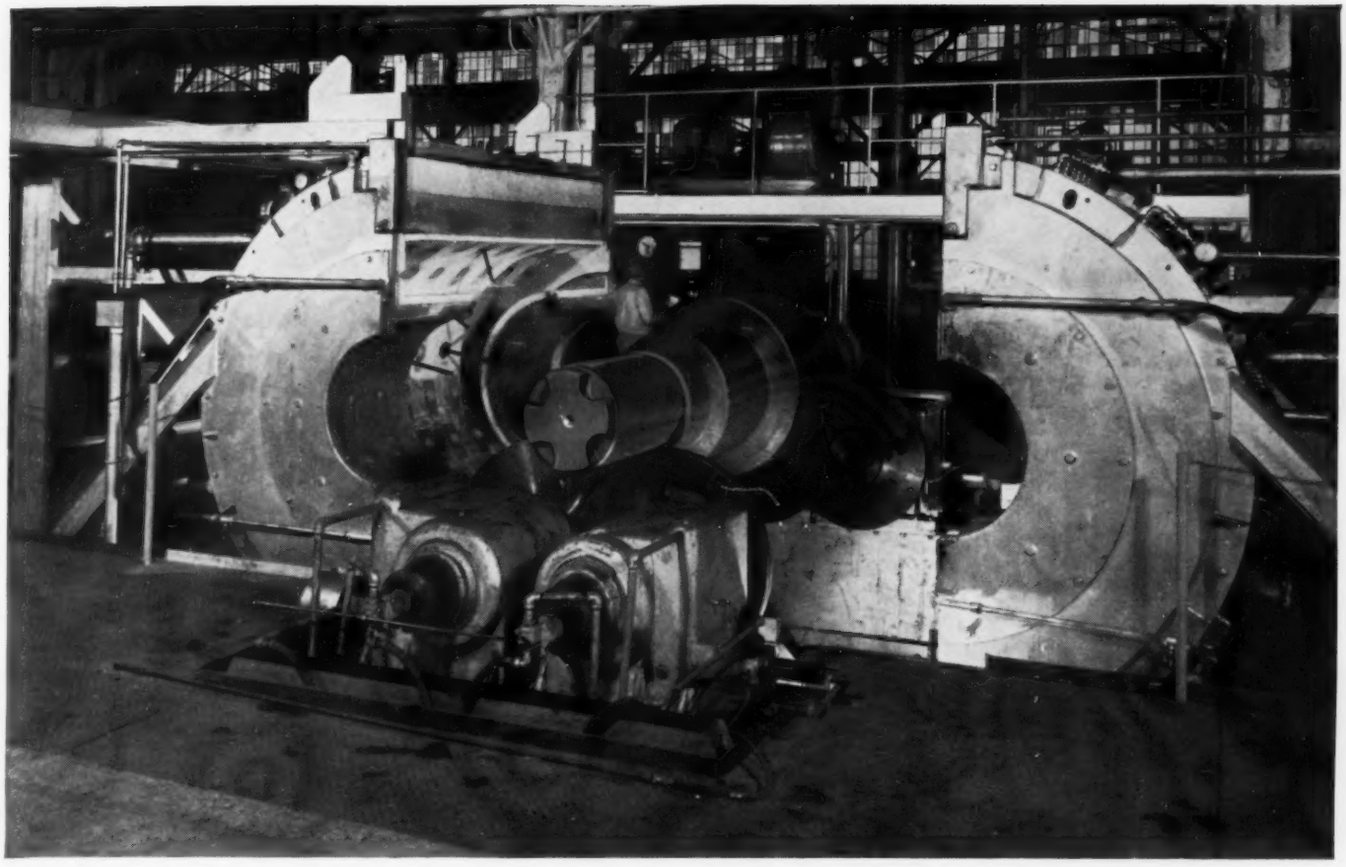

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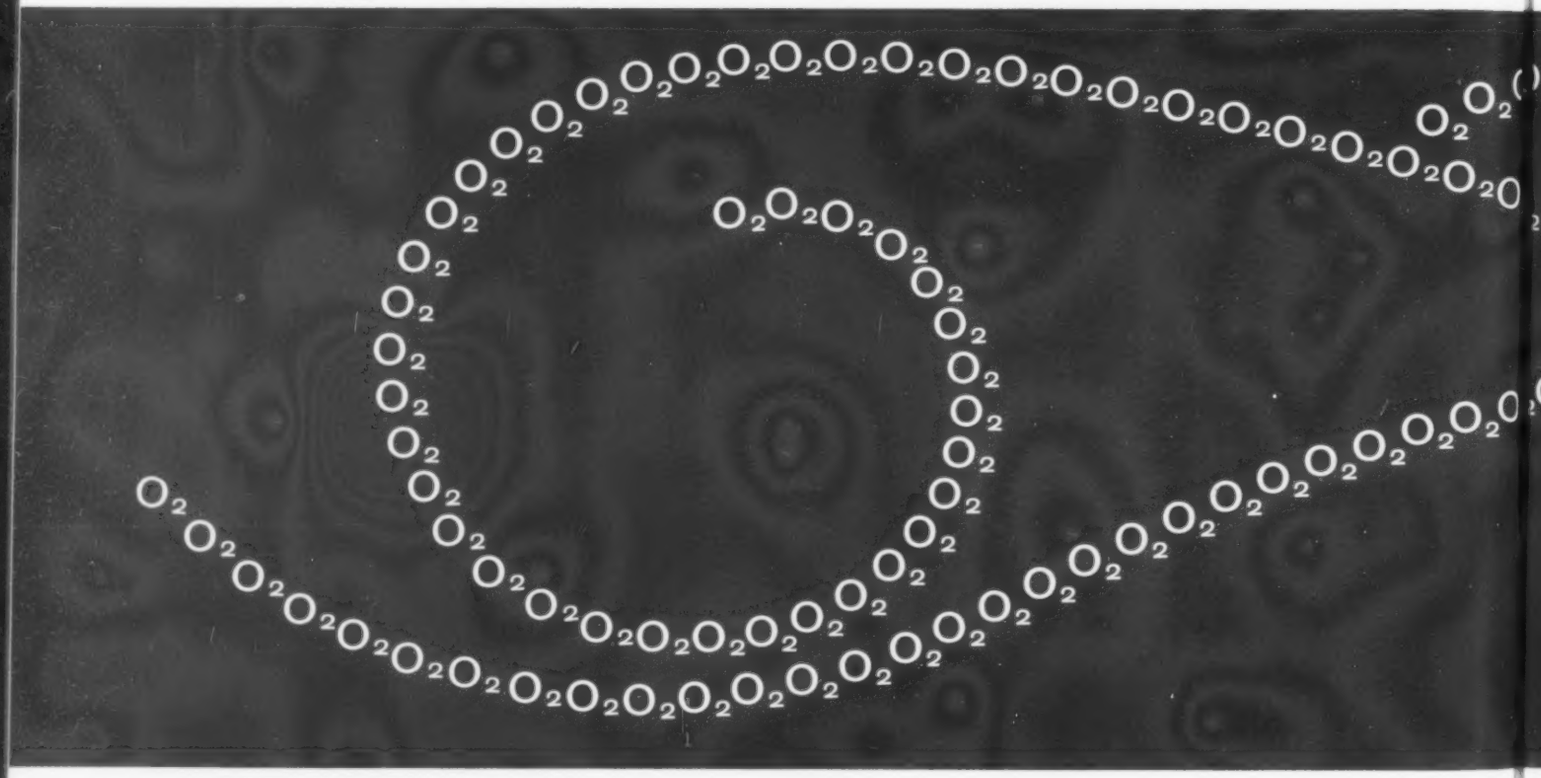

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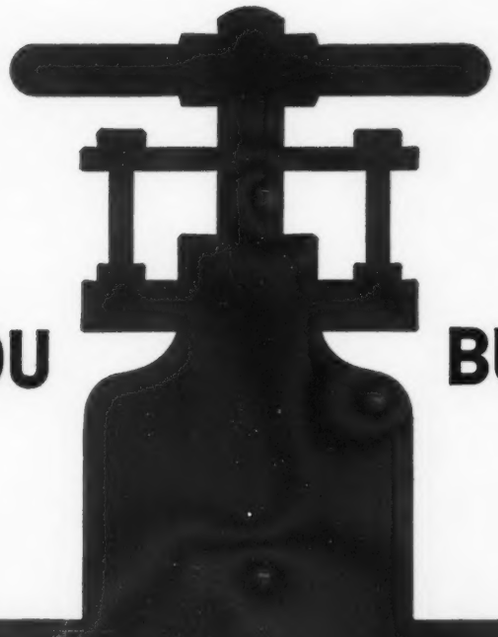

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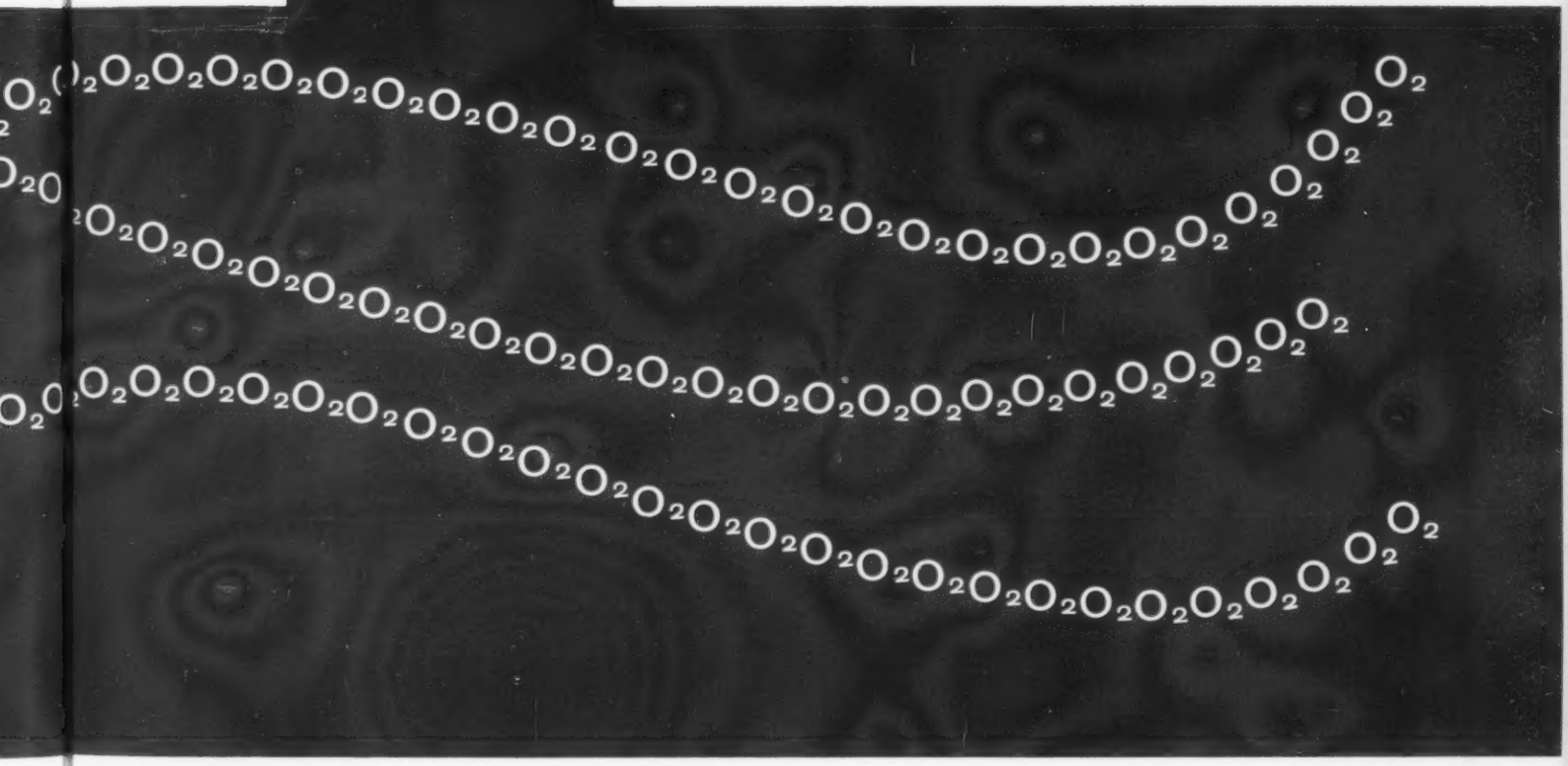

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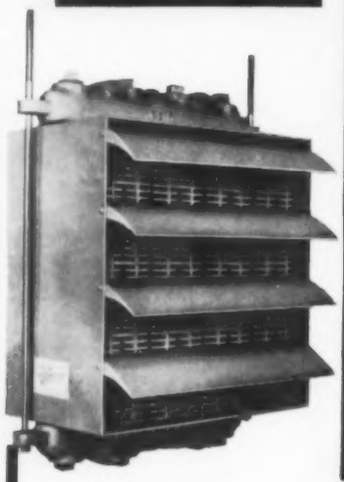

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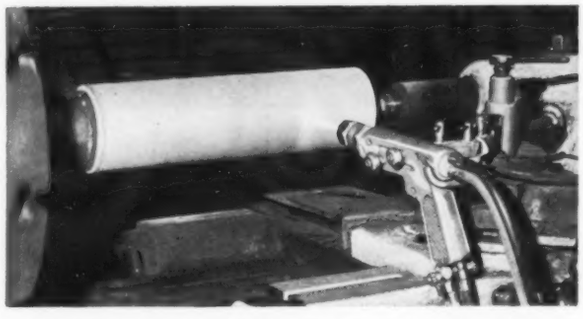

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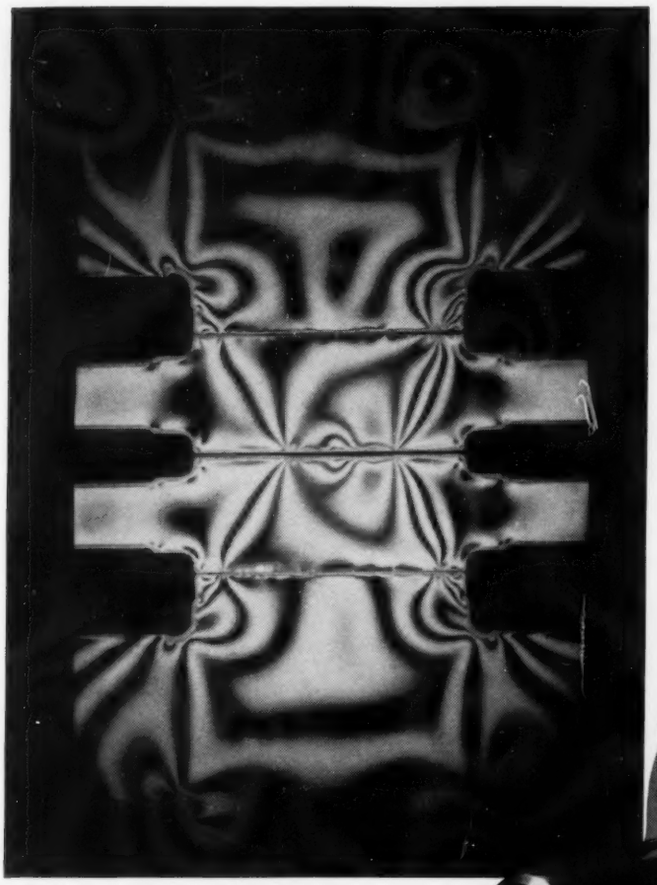

Photo-elastic study of four-high mill showing pressure patterns on roll surfaces.

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## . . . and produce fine *Micro Lustre*® finishes

Extensive photo-elastic studies of roll pressures by Midvac engineers reveal a build-up of pressure patterns in certain areas. For long life, rolls must be able to stand these extreme pressures at all points.

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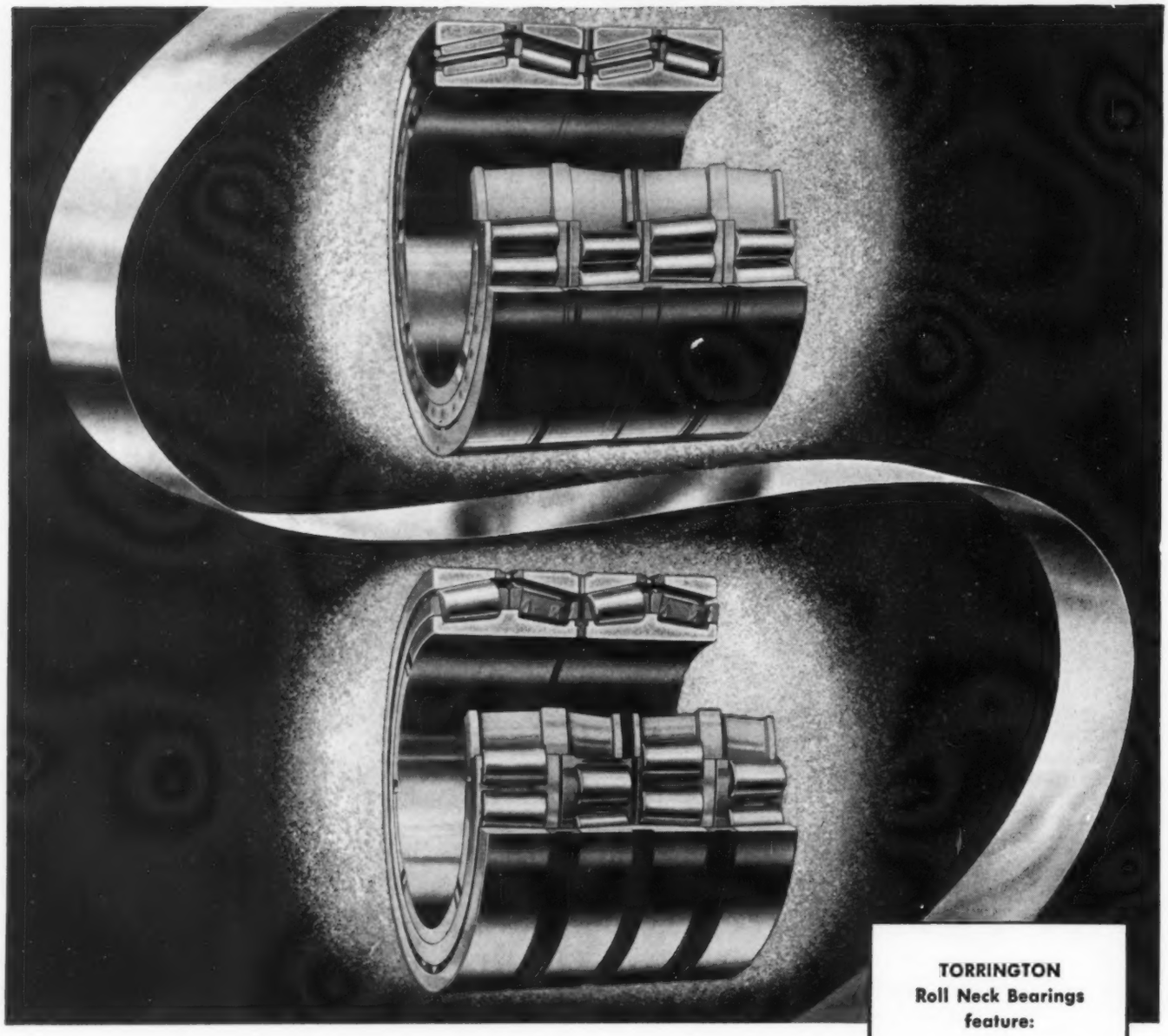

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**feature:**

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- advanced heat treatment
- minimum cross section
- high radial and thrust capacity
- resistance to shock loads
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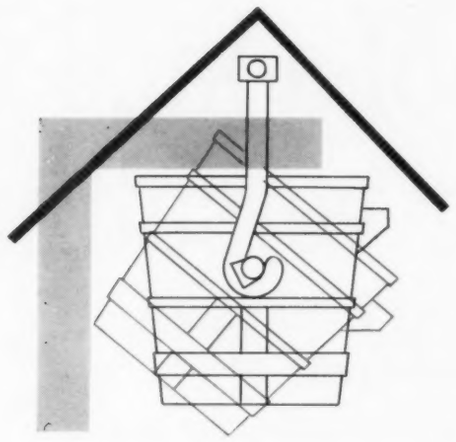

# STEEL ANGLES

WHEN the American Iron and Steel Institute decided against publishing the annual capacity for the steel industry at the beginning of this year, there was considerable comment, some of which was adverse. Without this figure it was impossible to calculate accurately the week by week operating rate for the steel industry, and some complained that one of the principal indicators of economic activity was no longer available.

So great was the attachment to this barometer that many newspapers and magazines continued to estimate the operating rate, based on the relationship of weekly ingot production to an approximation of present steel capacity. The capacity figure was arrived at by adding several million ingot tons to last year's figure of 148,600,000 tons.

The controversy about the operating rate points up two problems:

1. Does the rate of operations truly represent activity in the steel industry?
2. How accurately, in the light of modern technology, can the industry's capacity be stated?

In the first instance, it must be said that the ingot rate alone is not the best indicator of steel industry activity, for several other significant factors must also be taken into account. Among these, total ingot production is of great importance. In 1948, for example, the industry produced 88,000,000 tons which represented an operating rate of 94 per cent. Only six years later, in 1954, the industry again produced 88,000,000 tons, but total capacity had grown to such an extent that this identical ingot production constituted an operating rate of only 71 per cent. In 1958, an ingot output of 85,000,000 tons represented only 60 per cent of capacity. So it is evident that steel industry activity cannot be measured by the operating rate alone, since the same amount of production can indicate feverish activity, and just six years later, a recession rate of operations.

It is important that we stress total production, which, incidentally, the industry did, by publishing an index of production based on 1947–49. This, however, did not get widespread acceptance as analysts and economists continued to quote the more familiar operating rate.

To present an adequate picture of steel industry activity, a number of other published statistics should be used in conjunction with the operating rate and total production. We would have a much more balanced view of steel industry activity and its place in the economy if a series of statistics on industry employment, payroll, profits and steel shipments were used in place of, or in conjunction with, the figure representing the operating rate. Further, upon analysis, it can be shown that the ingot rate alone at times may even misrepresent industry activity, for it is possible that holidays, bad weather or production for inventory can distort the picture. Nevertheless it was used, and often without qualification, so that the picture at times was distorted.

The second point, namely, the accuracy with which capacity can be determined, presents an even greater problem in view of the very rapid advances in steelmaking that have taken place in the last few years. By the use of oxygen it has been possible to increase the production of a given furnace substantially. In fact, in some instances, the results have been little short of fantastic. The change has been so revolutionary that the head of a large steel company made the statement that it might be possible to virtually double our steelmaking capacity through the proper use of oxygen without building another furnace. This comment may be a bit rhetorical. However, if it is only half true, and most people believe that it is at least that, we could add 75,000,000 tons to our steelmaking capacity without building any more furnaces. The chief problem in this expansion of capacity would be breaking bottlenecks in getting materials to the furnace and the steel away from it, as well as balancing out the capacity of blast furnaces, coke ovens and other facilities. Another problem which arises is the evaluation of the capacity of oxygen converters which are now being installed. Many of these, rated at first at 65 tons per heat, have consistently produced better than 80 tons.

No one questions the fact that the use of oxygen has been a boon to the industry, but it has made difficult the accurate estimating of capacity. For example, one steel company has open hearths with a rated capacity of over 3,000,000 tons as of January, 1960. The operators claim that by the use of oxygen lances, they can produce this amount with half the number of furnaces, and, thus, the others will be idle. The question arises, are these idle furnaces to be included in the capacity or not? The company has no need for them, yet, if they are allowed to stand, they can be put in use on relatively short notice, so it seems that they should not be excluded from the nation's capacity. Perhaps a special classification of stand-by capacity should be established to cover them and others which will receive like treatment.

These are some of the problems which will have to be considered in order to arrive at a realistic and accurate measure of capacity.

One further thought on capacity: this would be a good year for the industry to eliminate approximately 10,000,000 tons of obsolete high cost capacity from its books, since much of this has not been used in the last two years. ▲

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# Oxygen Steelmaking in the Ajax Furnace of the Appleby-Frodingham Steel Co.

by ALBERT JACKSON
Technical Director
Appleby-Frodingham Steel Co.
Scunthorpe, England
and
Technical Adviser on Steelmaking
United Steel Companies, Ltd.
Sheffield, England

*. . . . the Ajax furnace has proved its ability to produce quality steel from a high phosphorus hot metal charge with low refractory and operation costs . . . .*

IN 1950, in conjunction with United Steel Companies' research and development department, experiments on the intensive use of oxygen for bath lancing commenced at Appleby-Frodingham.

Two consumable steel pipe lances were inserted simultaneously through the furnace doors as soon as charging of molten metal was complete, and blowing continued with most of the fuel still on the furnace until the charge was melted. At this point the phosphoric primary slag was removed, lime added to form the finishing slag and lancing continued as and when necessary bringing the carbon content of the bath down to specification.

The details of these trials have been published elsewhere but the important conclusions of interest in this particular context were:

1. Intensive bath lancing during melting and refining gave a material increase in production.
2. The rate of wear on the refractories of the roof and downtakes was considerably accelerated with consequent increase in repair time and reduced furnace availability.
3. The intense brown fumes from the stack could make the process unacceptable if applied to all the steel furnaces.
4. While the production rate was increased the cost per ingot ton overall tended to show a small increase, although tonnage oxygen at that time was slightly more costly than it now is.

In view of this background intensive bath lancing during melting ceased. The application of oxygen during refining continued to a minor degree, but combustion oxygen applied for about two hr during charging continued as regular practice over the intervening years.

At the end of 1955 experiments were made in applying chrome-magnesite roofs to these large tilting furnaces and this proved successful.

This established the possibilities of using higher operating temperatures, and in the meantime significant developments had taken place in the manufacture of tonnage oxygen. Experiments on the application of lancing during melting and refining were restarted in May, 1957.

Initially a standard furnace was used for these experiments which, due to the difficulties of acquiring sufficient oxygen regularly, were not as comprehensive as might have been wished. In spite of this it was decided in mid-1957 to completely dismantle one modern furnace, with the exception of the hearth itself, and rebuild it specifically as an oxygen blown unit. In the meantime a tonnage oxygen plant was in the course of construction.

Ports, uptakes, slag pockets, regenerator chambers and flues were prefabricated. The furnace taken out of service on December 31, 1957 and 26 days later after

completing dismantling and rebuilding was commencing to heat up for production.

The reconstructed furnace differs in numerous details from any furnace of which the author has knowledge. Furthermore, the process differs very materially from the standard practice at Appleby-Frodingham. For convenience in distinguishing this development from existing plant and practice the code word "Ajax" is used for both furnace and process and this phraseology will probably continue until all the existing open hearth furnaces have been converted to Ajax.

## THE AJAX FURNACE

The experimental work on intensive oxygen lancing in a standard open hearth tilting furnace brought forward the following points:

1. Using high percentages of phosphoric molten iron resulted in the formation of very foamy slags, so the charge size had to be reduced to below 60 per cent of the standard furnace capacity.

2. Iron oxide fume quickly blocked the regenerators; the facilities for cleaning were inadequate and for various reasons could not be sufficiently developed to overcome this difficulty.

3. Air infiltration through uptakes, slag pockets, regenerators, flues and a waste heat boiler raised the gaseous volume to be passed through a gas cleaner to a figure several times the theoretical gaseous volume produced during lancing without fuel firing. This infiltration was further increased as the regenerators became blocked, a matter of only a few days with intensive application of oxygen.

When considering further development of the process and with these points in mind, it became necessary to decide whether the future use of oxygen lay in an open hearth furnace supplemented by oxygen, or in a furnace in which oxygen did the metallurgical work, but at the same time retained the advantages of the open hearth furnace for fettling and refining. The decision was made in favor of the latter alternative and this then brought in the following changes of design.

The maximum fuel input was to be 55 to 60,000,000 Btu per hr derived from coke-oven gas only.

The outlet for gases from the furnace was to be reduced to a diameter of 5 ft or an area of 19.5 sq ft. This is extremely small, by open hearth standards, for a furnace intended to be capable of a maximum weekly production of 6750 tons. This small outlet enabled the end banks of the furnace to be raised so that heavy foaming could better be contained in the hearth and charging capacity raised in consequence to about 70 per cent of standard open hearth capacity.

The gas burners were to be built into the four corners of the tilting hearth, so that the ports became merely inlets and outlets for hot air and waste gases, respectively. These outlets were completely encased in a continuous steel shell and small enough to be lifted off and changed when necessary by the overhead charging crane in a very few minutes, without interfering with the operation of the furnace.

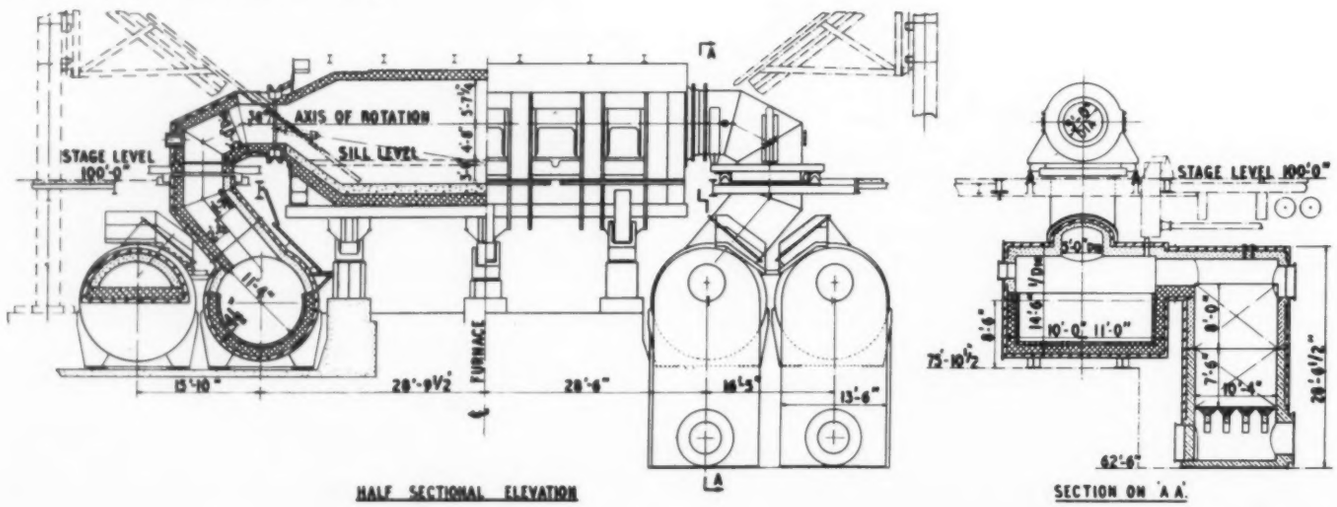
The slag pockets and regenerator chambers were to be cylindrical, with their long axes horizontal and vertical, respectively. They were to be enclosed by a continuous steel casing and be completely airtight, all manholes having lids, the joints of which are packed with asbestos and securely tightened by numerous bolts.

The flues were to be comprised of lined steel tubes right to the main stack flue, which is located 20 ft below ground, underneath the raw materials stockyard. It was believed that depth and earth cover would give a very low level of infiltration in this part of the flues and in consequence it was not altered. Subsequent trials showed that this was not the case, so in the third conversion this flue is also fully encased in a steel tube.

The regenerator chamber was to retain the same height as in an open hearth furnace, but its diameter inside the lining was to be reduced to 10 ft. This gives an area less than one sixth of that in a standard furnace and gaseous velocities more nearly comparable with a blast furnace stove than an open hearth furnace. However, its advantage is that it can be cleaned in a very few minutes by air lancing while the furnace is charging, and this is done every alternate day on each of the two regenerators.

Having reduced regenerators and slag pockets to these sizes it became possible to have a pair at each end

**Figure 1 — The regenerator design modifications and the complete insulation of the slag pockets and the uptakes have resulted in substantial fuel savings.**



one set in use and one being cleaned and repaired. Standard practice now is to change over as a routine after four weeks operation. This leaves adequate time for cooling down, cleaning out on day shift without urgency, and repairing in reasonably cool and comfortable circumstances.

The alternative below-stage slag pockets and regenerators and the changeable offtakes mean that a general repair consists only of the time necessary to dismantle and rebuild the furnace body. All other repairs are done while production continues.

The volumetric capacity of the gas cleaning plant was to be limited in relation to the low air infiltration anticipated from the design outlined. The waste gases were to pass first through the firetube boiler already acquired for the existing standard open hearth furnace.

The water-cooled lances at each end of the furnace were to be mechanically operated and pass through the offtakes into the furnace and hearth, being long enough to enable deep immersion in the metal bath if necessary.

All furnace controls were to be pushbutton operated from a centrally located desk which carries all operating indications. Recording instruments were to be housed in an air-cooled cubicle behind.

Oxygen was to be admitted in three ways, through lances, at the fuel burners for combustion and with the air intake through the regenerators.

The tilting hearth of the furnace was to have the end openings reduced in size and small circular water-cooled chills replace the larger oval ones.

The offtakes were to be mounted on a movable carriage so that they can continually be pressed toward the furnace hearth to maintain close contact between the water-cooled steel chills of the fixed and movable parts, thereby reducing infiltration to a minimum.

These various design factors satisfactorily achieved their purpose in the first furnace and were duplicated in those built subsequently. They are diagrammatically shown in Figure 1.

## THE AJAX PROCESS

Although this process is conducted in the hearth of an open hearth furnace, it is for most of its tap-to-tap cycle identical in principle with the modern oxygen steelmaking processes. Only during charging and refining does it operate as an open hearth furnace.

When tapping is complete, the furnace still contains some 20 to 30 tons of molten steel and all of the refining slag from the previous heat (7 to 14 tons).

Ore (about 12 tons) and limestone or lime (about five tons) are charged and the furnace fettled with dolomite. Molten iron is then brought from the active mixer in a series of 70-ton ladles. Between tapping and charging the first or second ladle of metal the furnace is fired with coke-oven gas (55 to 60,000,000 Btu per hr) and combustion accelerated by the admission of about 15,000 cfhr of oxygen, which enters through two jets just below the coke-oven gas inlet in each of the two burners. The theoretical requirement of hot air enters through the regenerators.

As soon as charging of the second ladle of molten metal starts the coke-oven gas and combustion oxygen are shut off completely and oxygen for lancing is switched on and used at rates up to 75,000 cfhr. The volume of hot air admitted through the regenerator is adjusted to 5.5 times the oxygen volume passing through the lance, thus almost all of the carbon monoxide evolved from the metal is burned in the furnace hearth. This is confirmed by instruments analyzing the waste gases. Unfortunately, no way has yet been found which prevents intermittent blockage of the gas pipes between furnace and instruments with iron oxide dust.

About 30 min after charging is finished the complete analysis of the charged molten metal is received and the necessary additions to the oxides added originally are put into the furnace.

The oxygen required to bring the bath analysis to about 1.0 per cent C and 0.1 per cent P is calculated and noted on the oxygen volume integrator and recorder. When this quantity has been used the furnace operator receives a visual or audible signal. He then samples the bath for metal and slag and takes a temperature reading using the immersion pyrometer.

The oxygen lance is withdrawn, and by means of electrically operated valves, coke-oven gas is instantaneously put into the furnace. This allows foaming to subside and the slag condition to be inspected. If satisfactory, as is usually the case, the slag is removed by tilting the furnace. If not, appropriate adjustments are made which can consist of further lancing, melting down with fuel or adding further molten iron or oxides and lime.

When making ordinary quality or soft steels the only adjustment necessary may be a few more minutes of oxygen lancing. For higher carbons and the more difficult open hearth steels, the bath condition must be much more carefully adjusted at this point by the possible variants mentioned above.

By the time the slag has been removed the bath analyses are available and additions of lime are made in accordance with existing slag control procedure.

The volume of oxygen required to bring the bath to 0.3 per cent C above final specification is now calculated, but the quantity added is subdivided into oxygen derived from ore and oxygen through the lance. This subdivision is dependent upon bath temperature, i.e., a greater proportion of ore is used if the bath is hotter than average, and the reverse is true if the metal is too cold for this particular point in the process.

The length of time during which oxygen lancing is interrupted for slag removal and feeding varies from nil in the case of "dead softs" to 45 min for high carbons or special qualities. In the latter instance it is most important that slag removal is clean and complete, otherwise reversion of phosphorous may take place during the final phases of refining. This is not an important difficulty when making "dead softs," although the slag being removed contains between 16.0 and 19.0 per cent $P_2O_5$.

Fuel is shut off for the final oxygen blow, and when the calculated oxygen volume has been added a sample is taken for complete analysis. This is normally to specification, except for carbon, and for this the bath is sampled every seven min by carbometer. A spectrograph is now being installed. At this point the time at which lancing ceases and fuel firing recommences is decided. For soft steels lancing may continue until the furnace is almost ready to tap. In the higher carbon ranges, depending on the degree of bath stability required,

**Figure 2 — The Ajax process, using 100 per cent hot metal, has operating costs substantially under the standard open hearth practice.**

fuel firing may continue for upwards of an hr after oxygen lancing ceases.

Tapping takes place by tilting the furnace shown in Figure 2 and pouring off two 110-ton ladles in rapid succession, again leaving behind some steel and all of the refining slags.

Typical charges for ordinary and carbon steel for "upending" quality are shown diagrammatically in Figures 3 and 4.

The average raw materials, in lb per ingot ton, used in the steelmaking furnaces is as follows:

| | *Lb* |
|---|---|
| Mixer metal | 2120 |
| Finishings | 21 |
| Ore | 190 |
| Lime | 48 |
| Limestone | 85 |
| Dolomite | 58 |

## IRON ANALYSIS

The process makes use of molten iron produced from all-British ores. These are very low grade but as they can be mined and delivered to the works at a relatively low cost the molten iron is made at a price below that of iron from imported higher grade ores. The analysis as it leaves the blast furnaces is:

| | *Per cent* |
|---|---|
| C | 3.7 |
| Si | 0.6 |
| P | 1.3 |
| Mn | 0.9 |
| S | 0.05 |

This iron is passed through a gas-fired active mixer with a maximum holding capacity of 550 to 650 tons. While in the mixer it is fed with ore, limestone and light or dirty scrap, the following being representative figures of the additions in lb per net ton:

| | |
|---|---|
| Ore | 51 |
| Limestone | 43 |
| Scrap | 50 |

The iron analysis leaving the mixer is:

| | *Per cent* |
|---|---|
| C | 3.5 |
| Si | 0.2 |
| P | 1.1 |
| Mn | 0.5 |
| S | 0.05 |

## PRODUCTION RATE

In the first two campaigns there were various teething troubles, men to be trained and considerable repair time due to rapid roof wear. This difficulty was overcome later and blowing rates increased. The last two full campaigns as shown in Table I on B Ajax have shown an increase of 51 per cent on its former production rate

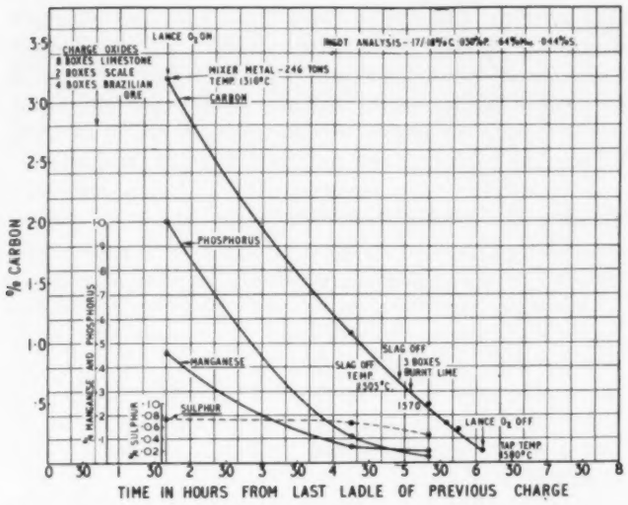



**Figure 3 — Typical processing of an ordinary steel heat shows that tap-to-tap time is approximately 6½ hr with about 4½ hr of oxygen lancing time.**

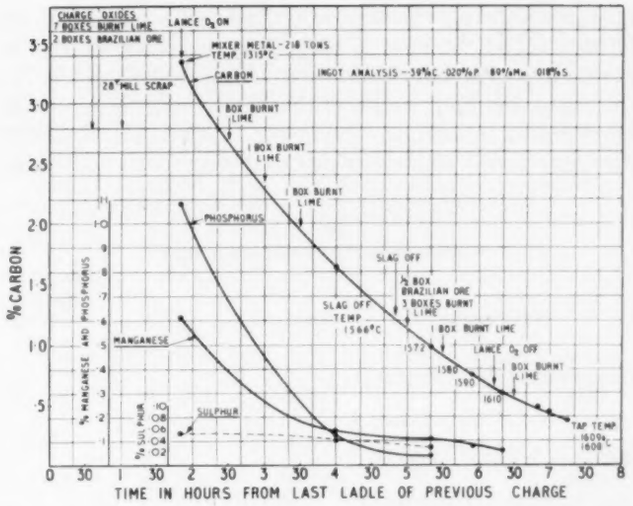



**Figure 4 — Typical processing of a heat of quality steel shows that although oxygen lancing time is roughly the same as for an ordinary heat, the tap-to-tap time is 7½ hr.**

as an all-basic open hearth, which was one of the company's most modern furnaces. The N Ajax, formerly a silica-roof furnace built 40 years ago, has shown an increased production since conversion of 102 per cent. In the last seven weeks B furnace blowing 75,000 cu ft oxygen per hr has produced 5613 tons per working week.

## OXYGEN AND FUEL CONSUMPTION

The total oxygen and fuel consumption per ingot ton shown as maximum and minimum per campaign are:

| | *Oxygen, cu ft* | | *Fuel — Btu × $10^6$* | |
|---|---|---|---|---|
| *Furnace* | *Maximum* | *Minimum* | *Maximum* | *Minimum* |
| B | 1287 | 1126 | 1.046 | 0.797 |
| N | 1466 | 1297 | 0.815 | 0.708 |

About 160 cu ft of the oxygen is used for combustion and the remainder for lancing.

In a given furnace the maximum oxygen normally goes with the minimum fuel consumption.

N furnace has been operated to continue blowing longer each charge than B and this accounts for the higher oxygen and lower fuel consumption.

Fuel consumption in standard practice was 4,000,000 Btu per ton, thus the Ajax requirement has shown a reduction of nearly 80 per cent as a return against the volume of oxygen used for lancing. The standard open hearth furnaces use about the same quantity of combustion oxygen as the Ajax.

## REFRACTORIES

The furnace has chrome-magnesite roof and linings. The hearth is magnesite brick with a dead burnt dolomite working lining.

The offtakes are lined with chrome-magnesite brick but magnesite-chrome is being tried.

The slag chamber was originally lined with magnesite in the lower half and chrome-magnesite in the upper. Experience has demonstrated that the temperature is not as high as was first believed likely so that good quality silica bricks now provide the most economic lining for the upper half.

The regenerators were also built with chrome-magnesite brick in the upper half and this lining in the first furnace is still in use. In subsequent furnaces the regenerator chambers are built with silica bricks in the upper and firebricks in the lower part.

Basic checker bricks were installed in the first furnace but rapidly collected dust and broke down when cleaning. Firebricks with 42 per cent $Al_2O_3$ now provide a satisfactory solution. The checkers can be easily destroyed by overheating and are protected by a

**Figure 5 — The Ajax furnace gas cleaner is capable of processing 1,500,000 cu ft of gas per hr, substantially less than the gas flow from an open hearth of similar capacity.**

thermocouple at the top which operates an alarm at 2460 F. The furnace is then reversed but when the reversal period falls below seven min either gas is reduced, if on fuel, or excess air is blown through the regenerator if lancing. The latter happens infrequently and only for short periods due to intense bath reactions.

**TABLE I**
**Production Rate of Ajax Furnace**

| Campaign | Furnace | Ingot tons | Tons per working week |
|---|---|---|---|
| January 28, 1958 to August 14, 1958 | B | 105,787 | 4561 |
| August 14, 1958 to February 8, 1959 | B | 102,033 | 4742 |
| February 8, 1959 to July 24, 1959 | B | 102,604 | 5147 |
| June 6, 1959 to December 13, 1959 | N | 113,282 | 5210 |
| July 26, 1959 to January 5, 1960 | B | 96,684 | 5063 |
| December 13, 1959 to June 11, 1960 | N | 119,729 | 5191 |

Table II shows the total refractory brick consumption and indicates the low figures for below-stage bricks which are essentially silica and firebrick.

**TABLE II**
**Ajax Furnaces, Refractory Brick Consumption for Running, Intermediate and General Repairs***

| Ingots tons per campaign | 102,604 | 113,282 | 96,684 | 119,729 |
|---|---|---|---|---|
| Tons per working week | 5,147 | 5,210 | 5,063 | 5,191 |
| Silica brick, lb per ingot ton | 1.70 | 0.51 | 1.53 | 1.01 |
| Firebrick, lb per ingot ton | 1.63 | 0.74 | 2.63 | 0.89 |
| Magnesite, lb per ingot ton | 0.89 | 0.89 | 2.41 | 3.45 |
| Chrome-magnesite, lb per ingot ton | 13.98 | 12.53 | 10.64 | 11.73 |
| Total | 18.20 | 14.67 | 17.21 | 17.08 |

* Last four campaigns, short tons.

Table III shows comparable figures for two years on the ordinary furnaces using basic roofs.

**TABLE III**
**Open Hearth Furnaces, Refractory Brick Consumption for Standard Practice with Basic Roof****

| | 1957/58 | 1958/59 |
|---|---|---|
| Ingot tons | 1,336,742 | 724,256 |
| Silica brick, lb per ingot ton | 15.83 | 12.67 |
| Firebrick, lb per ingot ton | 3.90 | 5.28 |
| Magnesite, lb per ingot ton | 1.87 | 1.68 |
| Chrome-magnesite, lb per ingot ton | 10.14 | 9.82 |
| Total | 31.74 | 29.45 |

** Short tons.

In the early campaigns considerable trouble was experienced due to local roof wear above the lance impact area on the bath. This necessitated small patches in the basic roof every ten days. Modified lance design obviated this trouble and the necessity to patch ceased, the roof life then reaching about seven weeks and the roof brick consumption fell from 16 lb per ingot ton—to six lb per ingot ton.

In September, 1959, a roof was installed consisting of a checker pattern of burnt magnesite and chrome-magnesite bricks laid alternatively with steel sheets between all adjacent faces. The principal aim was to neutralize the pressure resulting from oxide absorption in the chrome-magnesite bricks by the contraction in the magnesite bricks. A secondary factor also helped for it was found that the magnesite and chrome-magnesite cracked at differing distances behind the hot face, and this was believed to account for the fact that the major spalling which formerly gradually spread across the whole roof, ceased to occur with the checker pattern roof. Wear was uniform and the magnesite bricks continually projected slightly beyond the chrome-magnesite at the hot face. This innovation has raised the roof life to 12 weeks and the consumption of roof brick will show a further reduction when the next summary is made.

Since the furnaces were changed from standard silica open hearth to Ajax the height from sill level to the crown of the roof inside has been raised in the small furnace from 8 ft-0 in. to 10 ft-3½ in. and in the larger from 8 ft-0 in. to 11 ft-2 in. The rise is now 4 ft-3 in. and 5 ft-1 in., respectively.

Tables II and III show the considerable reduction in the refractory brick consumption which has taken place and this is reflected in the repair cost. This latter is not reduced entirely in proportion to the brick consumption; however, because there is a small increase in the quantity of basic bricks which partially offsets the major reduction in the less costly silica and firebricks.

The reduction in cost and consumption is also due to a significant degree to the use of interchangeable offtakes, slag pockets and regenerator chambers. In normal open hearth practice the necessity to get the furnace back into commission quickly and ensure that it lasts a full campaign involves mechanical wrecking, blasting and the replacement of important quantities of brickwork not actually worn out.

In the Ajax furnace the slag pockets and regenerators are changed over on a regular cycle of about four weeks. After making all allowances for this changeover, including raising to operating temperature, their availability averages 99.14 per cent.

The spare furnace sections can be steadily repaired over four weeks if necessary. They are slowly cooled and wrecked with care. Furthermore, it is unnecessary to remove large quantities of undamaged brickwork to meet the prospective needs of a long campaign because the life is broken down into four-week periods. As regards the furnace end offtakes, these are so easily changed that any partially worn out end which appears likely to give a further week's life is put back when the hearth and roof are renewed. Thus the only part which now needs to be repaired at high speed is the body of the furnace itself.

Port ends, offtakes, slag pockets and regenerator chambers are all well insulated. This leads to the possibility that when the basic lining wears thin it may suddenly collapse without showing hot on the outside. The life of the insulation will then be short and the steel structure will be rapidly burned through or a changeover becomes necessary at some inconvenient time. To obviate this possibility the temperature of the known critical parts is measured by contact pyrometer at intervals from seven days upwards, depending on the

expected life of the section under examination. The temperatures normally recorded vary from 250 to 300 F. As soon as they increase to about 525 F it is necessary to consider making a change within the next few charges. The aim is to changeover on the weekend under normal circumstances.

## IRON LOSSES AND RECOVERY

Iron losses from the furnace system are recovered in three groups slag-pocket slag, flue dust and dust from the gas cleaner.

The following are average quantities during a total ingot production of 193,736 tons:

| *Recovery area* | *Per cent Fe* | *Lb per Ingot ton* |
|---|---|---|
| Slag pocket | 33 to 40 | 7.9 |
| Flue dust | 50 to 58 | 2.6 |
| Gas cleaner | 65 | 14.1 |

These contain in total 13.5 lb Fe per ingot ton equal to 0.675 per cent.

All of these materials are returned to the blast furnaces and their iron content recovered. In normal open hearth practice no recovery is made from the slag-pocket slag while a significant amount of oxide is lost in the waste gases leaving the chimney top, thus the irrecoverable loss of iron is significantly greater than in the Ajax modification.

A typical analysis of the pocket slag which goes to the blast furnaces is:

| | *Per cent* | | *Per cent* |
|---|---|---|---|
| $SiO_2$ | 3.54 | S | 0.039 |
| MnO | 1.22 | $P_2O_5$ | 5.62 |
| CaO | 15.80 | FeO | 1.16 |
| MgO | 16.42 | $Fe_2O_3$ | 51.28 |
| $Cr_2O_3$ | 2.35 | Fe | 36.8 |

## OPERATING COSTS

A comparison is shown below which expresses the Ajax operating costs as a percentage of those achieved on standard open hearth practice using basic roofs.

| | *Standard* | *Ajax* |
|---|---|---|
| Wages | 7 | 5 |
| Operating supplies | 13 | 12 |
| Furnace fuel | 30 | 6 |
| Oxygen | 1 | 8 |
| Dustcatcher | ... | 2 |
| Waste heat credit | 3 | 2 |
| Maintenance (including depreciation) | 31 | 21 |
| General services | 15 | 10 |
| Departmental | 6 | 6 |
| Total | 100 | 68 |

## CAPITAL

The average cost chargeable to capital for the conversions has averaged approximately $5.60 per annual ton on the increased production achieved. The reduction in ingot cost has recovered this cost of conversion in well under two years. The major items of capital cost are the gas cleaning plant, the new slag-pocket and regenerator chambers, flues and uptakes.

It is estimated that if Ajax furnaces were built on a green field site for the practice described the capital cost would be between 60 and 65 per cent of that required for equivalent production from the standard open hearth furnaces. This difference arises from the increased production per unit, the ability to prefabricate almost all of the below-stage structure, the simple foundations and the possibility of erecting the prefabricated work very quickly on site.

## HEAT UTILIZATION

Table IV shows a typical example of the distribution of the heat input to the process based on making one ton of ingots:

**TABLE IV**
**Heat Balance — with Boiler**

| Heat Input | Btu × $10^6$ per ingot ton |
|---|---|
| Molten iron charged | 10.58 |
| Oxidation of Si, Mn, P, Fe and C to CO | 8.76 |
| Combustion of CO to $CO_2$ | 7.33 |
| Fuel, coke-oven gas | 8.03 |
| Total | 34.70 |
| **Heat Out** | **Btu × $10^6$ per ingot ton** |
| Molten steel, tapped | 12.31 |
| Molten slag, 300 lb | 2.44 |
| Decomposition of limestone | 0.758 |
| Decomposition of ore | 3.050 |
| Waste heat boiler, 401 lb steam | 5.016 |
| Steam cooling on furnace, 155 lb steam | 1.938 |
| Total | 25.512 |

The total heat out used as shown is 74 per cent of the heat input. If the standard open hearth practice is calculated in a similar manner using ore instead of oxygen and normal fuel a comparable figure is 54 per cent.

This heat utilization figure in the Ajax furnace can probably only be improved upon in the modern basic oxygen processes if they consume the bulk of the evolved carbon monoxide in the vessel itself and recover most of the heat in the gases leaving as usable steam.

## SUMMARY

These experiments on intensive oxygen lancing commenced in 1957 with the object of obtaining an additional production of about 225,000 tons of ingots per year from existing furnaces, which were mostly modern fully instrumented furnaces already using linkages between roof temperatures and fuel input, fuel input and air supply and furnace pressure and chimney draft.

The early trials using intensive oxygen lancing in standard furnaces gave outputs on individual charges of over 60 tons per hr, using 100 per cent of molten phosphoric iron. Fuel was brought down to below 1,500,000 Btu per ton and oxygen to 1600 to 1800 cu ft per ton.

Continuing operation soon showed that these production rates could not be maintained indefinitely if the furnace was to have a reasonable life so the rate of oxygen lancing was reduced from 120,000 cu ft per hr in a standard open hearth to about 45,000 cu ft per hr in the

first Ajax conversion. Subsequent experience has allowed the oxygen rate to be raised to 75,000 cu ft per hr and the roof life from about four weeks with a small patch every ten days to a run of 12 weeks without a roof patch.

The economy of the operation has steadily improved and the operating cost (above materials cost) is down to an average of 68 per cent of standard practice. It is planned to convert eight furnaces in total to this process with an increase in annual production of 700,000 tons.

The process has still further possibilities to be explored. Progress to date has brought its competitive possibilities much closer to the basic oxygen processes using phosphoric iron, than present open hearth practice. Furthermore, for the manufacture of mixed grades of open hearth carbon steel it has the advantages of the open hearth furnace for finishing the charges, coupled with the advantages of the basic oxygen processes for its metallurgical refining. Under these circumstances it is doubtful whether there is any other process equally satisfactory in its ability to make varying steel qualities at the same ingot cost.

# Discussion


PRESENTED BY

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**ALBERT JACKSON, Technical Director,**
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**Graham Research Laboratory,**
**Jones & Laughlin Steel Corp., Pittsburgh, Pa.**

**L. B. LUELLEN, Assistant to the Vice President,**
**Planning and Research, Inland Steel Co., Chicago, Ill.**


**J. A. Glasgow:** The reconstruction and altering of existing steelmaking equipment at the Appleby-Frodingham Steel Co. to increase production 50 per cent above that of the all-basic furnace and 100 per cent above that of a silica furnace with a corresponding decrease of 32 per cent in operating costs is a remarkable achievement.

The development of the Ajax furnace has been an exceptionable contribution to steelmaking practice. The progress from the initial use of consumable oxygen lances through the wicket holes in the furnace doors to the water-cooled roof lances with the accompanying operating problems in furnace maintenance resulting from the increased use of oxygen has been an outstanding, commendable job very well done.

The experimental work which developed changes in the design of port ends, uptakes, slag pockets and checkers to a double system to allow 99.14 per cent furnace availability and permit rebuilding at a normal pace is phenomenal.

**D. L. McBride:** After hearing the results obtained with the Ajax furnaces one wonders whether similar improvement could be obtained in American open hearth shops using an entirely different metallurgical charge.

We do not believe that many American open hearth operators would have had the temerity to attempt to sell their management on making such drastic changes in open hearth furnaces in their own shops.

The unusual arrangement at the port ends, slag pockets and checkers appears to offer advantages from the standpoint of maintenance and furnace availability, but the Ajax design would seem to require considerably more space between furnaces than is available in most American open hearth shops. In judging the potential value of the design, consideration must be given to the recent and demonstrated performance of several American open hearth shops operating with all-basic roofs, oxygen roof lances and charged with 25 to 50 per cent scrap. Some shops have sustained a performance matching the tons per hr and refractory consumption of the Ajax furnaces, but have used about twice as much fuel and only half as much oxygen. It would be enlightening to hear the author's estimate of the performance of an Ajax furnace if it was charged with 25 to 50 per cent scrap and American type low phosphorus hot metal.

**Albert Jackson:** We have seen much information on the use of oxygen for bath lancing in America and many other countries, but have not yet seen any information, based on continuous operation over a reasonable period, wherein the total cost for fuel and oxygen was as low as that obtained in the Ajax furnace, even in plants using a very much lower metallurgical load. Nor have we seen fuel consumption per ingot ton as low in any normal open hearth furnace assisted by the use of oxygen.

We think this advantage arises because the regenerators, slag pockets and uptakes are fully insulated and completely encased in steel so that no air infiltration can take place. If such methods were used in a standard open hearth furnace, fuel economy per ingot ton would be improved.

If American iron was used in the Ajax furnace the output rate would be greatly improved because there would be about 1.00 per cent P less to be oxidized, which would give a considerable saving in furnace time, oxygen and fuel per ton.

The availability of duplicate slag pockets and regenerators is a considerable advantage as it allows time for these to cool before wrecking and repairing so that the work is very much less arduous for the men concerned and they can in consequence take more care in wrecking and so reduce the brickwork and cost necessary for repairs.

Our furnaces need no more space than many seen in America. The smallest furnaces are built on 117-ft centers, and the largest on 127-ft centers.

If the Ajax furnace was charged with scrap and American iron, as yours are, it would go just as fast if the same amount of oxygen was blown in for lancing and charging took place at the same speed.

**P. J. Koros:** We are interested in the relatively low fuel rate reported by the author for the Ajax furnaces in comparison with normal open hearth practice. Assuming a fuel rate of about 3,500,000 Btu per ton, and about 15 per cent infiltration into the outgoing end of the furnace, steel encasing the checkers

can save about 300,000 to 400,000 Btu per ton. Shortening the heat cycle from nine to six hr, tap-to-tap, can account for the saving of another 300,000 Btu per ton. The balance of the fuel savings of course are obtained from the replacement of part of the charge and feed ore with gaseous oxygen.

Has the use of the high oxygen flow rates, with its concurrent stirring and heating, aided in desulphurization?

What type of lance nozzle do you use? What changes in tip design did you make to improve roof wear?

In the paper reference is made to green site plant economics. Would you seriously consider building a new Ajax shop on such a location or would you go into one of the oxygen converter processes?

**Albert Jackson:** If all our furnaces were already Ajax furnaces and then we were asked to make another million tons of dead soft steel, I think the answer would be a simple one, but if the steel qualities varied widely from day to day as in many open hearth plants, a decision would be much more open.

We built our first Ajax furnace because we wanted an extra 3000 or 4000 tons a week for current production increases.

After this it was decided to add a new rod and bar mill, so we then wanted in total a further 700,000 tons a year. We had two possibilities. One was to continue using the standard open hearth and put in 700,000 tons a year of an oxygen blowing process, and the other was to convert all the existing furnaces to Ajax. We had the cost of our standard open hearth practice and we had the cost of Ajax practice. From these figures we could estimate what the cost of oxygen converter steel would have to be to compete with Ajax steel. Having found this and added the return on capital as well, the answer was simple, we just went on and installed the Ajax process. You must also remember we are not comparing ourselves with the LD process; we are comparing ours with the LD-AC, which has to take off an intermediate slag to remove the high phosphorus in our iron.

Our last gas cleaner specification (Figure 5) has a maximum of 1,500,000 cu ft per hr. Many of your open hearth furnaces in America with gas firing would be thinking of maybe 3,000,000 cu ft an hr, so there is a capital saving in the cost of the gas cleaner which goes a good way in paying for the infiltration free flue which helps to keep the gas volume down.

Apart from the saving in capital and operating cost of the gas cleaner, the prevention of infiltration in the 70-ft flue under the stockyard pays for its total cost in extra steam recovery alone in six or seven years.

It is quite interesting the way this process does remove sulphur. Some time ago we did a lot of investigations on the sulphur pickup by the slag. We found how much was in the slag, how much came from the iron and how much from the gas. With normal coke-oven gas operation there was a total pick-off during the operation of 23 lb of sulphur. Using desulphurized gas there was a loss of three lb. That is a total difference of 26. But in the Ajax process the average loss over the long period was 37 lb, so it has a strong desulphurizing action. It does much more desulphurizing then desulphurizing the coke-oven gas in a standard furnace.

The original lance had a single central hole, the improved type has three holes or six holes. We are still working on this problem.

**Albert Jackson:** The lime used is not related to sulphur. It is related to phosphorus. I have some slags here in which the sulphur in the slag was 0.078 per cent, so it is a long way from having as much as it will carry. That is, with normal irons the lime necessary to carry away the phosphorus will also take all the sulphur we need to remove.

**L. B. Luellen:** Several of the specific features of the Ajax furnace appear to have considerable potential for wider application. One of these is the checker pattern roof the author described in his paper. I do not think anything closely similar to this has yet been tried on American furnaces, and it looks like a highly logical approach. A second Ajax development with major implications is the bold treatment they have applied to the downtake, slag pocket and checker chamber sections. The advantages to be gained in conjunction with oxygen application to open hearths appears to be very substantial. The Ajax approach in these areas will bring a completely checkerless and otherwise more simplified furnace considerably closer.

One point of special interest to me is that the Ajax process is carried out with a charge of 100 per cent hot metal, exclusive of charge oxides. The scrap generated from the Ajax production is shipped about thirty miles to the electric furnace facilities of an associated company. This arrangement was based on problems peculiar to the parent company, but it encourages the thought that the same principle might be advantageously applied within a given group of open hearth shops. Almost invariably the production rates of our older open hearths have long been seriously limited by inadequate scrap charging facilities. Even our most modern shops will be unable to very far extend the new roof-lance techniques without coming up against the same bottleneck. In the past we have pretty much thought of these problems on a shop by shop basis, but perhaps a program of shop specialization for predominately hot or predominately cold charges might well provide better over-all economics. In such an approach shops with adequate metal handling facilities and with head room for roof lances, higher roofs, etc., would be adapted for 75 to 100 per cent hot metal charges. One of the older shops would then be chosen to handle predominately cold metallics and would be revamped as extensively as necessary to provide entirely new methods for very fast scrap charging and melting. The over-all hot metal to cold metallic ratios could be kept substantially the same.

The Ajax oxygen lances are positioned at about 40 degrees. This is probably the most practical way to get lances into tilting furnaces, but it would be of interest to know how such angular introduction of the oxygen compares with a vertical lance from the standpoint of oxygen efficiency and splash pattern.

**Albert Jackson:** The lance impact is actually at 27 degrees to the bath surface. This one is rather steeper, but within the lance the jet is turned to come out at 27 degrees. Water test and operating tests both brought us to the conclusion that 27 degrees gives us the best results which give least over-all attack from splashing on the roof and linings.

It is interesting to notice what happens as one increases the oxygen flow rate. First, it impinges on the bath and the splash goes forward as would be expected. As the oxygen flow is increased, it penetrates deeper and deeper, and the splash gradually becomes vertical and eventually reverses until it is going back toward the incoming port. The velocity and angle of impact are very important.

Our central research organization did some work for us when we first started by putting thermocouples through the roof over the jets to see what temperatures we were getting, and the best thermocouples they could get had a melting point of 3430 F. When we put on the oxygen at high velocity it would go up to this temperature in about ten sec and then completely melt. We have now very much overcome this difficulty.

We never thought in terms of a checkerless furnace, but believed we might have temperatures up to 3600 F, so our first thinking was to leave a gap between the edge of the furnace and the uptake chill to bring in an amount of air and cool down these outgoing gases. If we wanted a checkerless furnace we could take the checkers out and use the relatively small chamber just as a flue. We have not done this and they do put a lot of heat back in the furnace.

We have two plants which work closely together; one a fully cold charged plant in Sheffield, and the other a hot metal plant using only circulating scrap, which is in Scunthorpe.

The cold metal plant, which is getting obsolete, is now being scrapped and replaced by six 120-ton electric arc furnaces with 40,000-kva transformers to produce 1,500,000 tons per year from cold charges.

In the future the Ajax furnaces will use 100 per cent molten metal and all the process scrap will go to the electric arc furnace shop. This will release the pig iron used in the present open hearth plant which will be made into steel at its source by the Ajax process without the necessity to let it solidify.

In fact, exactly the same raw materials will be used but completely split into molten iron for Ajax smelting and cold scrap for the arc furnaces. ▲

# Available Translations

As a service to readers of the *Iron and Steel Engineer* a list of translations from foreign articles is being printed intermittently. Articles selected for this listing will be those of primary interest to the American steel plant operator. The papers may be obtained from the British Iron and Steel Industry Translation Service, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England. All correspondence concerning price, ordering, and so forth should be directed to that address.

1550 NURNBERG, W.: "Development of Drives and Electrical Machines In Rolling Mills," *Stahl u. Eisen*, 1959, May 14, pp. 694–703. The use of rectifiers in rolling mills has changed the type of electrical drive and that of all auxiliary machines in the last few years exploring the way toward complete automation. The development is traced and control equipment and measuring apparatus reviewed and discussed. (Abstract *J.I.S.I.*, 1959, Dec., p. 390 a–b.)

1614 ZIGEL', O. D.: "Peculiarities (and Defects) of the Formation of Billets Produced by Continuous Casting." Papers from "Continuous Casting of Steel," Proc. 1st All-Union Conference, October 17–19, 1955, Moscow, Akad, Nauk, 1956, pp. 164–177.

1618 SAMARIN, A. M.: "On Planning Scientific Investigations on the Continuous Casting Process." Papers from "Continuous Casting of Steel," Proc. 1st All-Union Conference, October 17–19, 1955, Moscow, Akad Nauk, 1956, pp. 267–270. Many of the problems which will have to be solved before continuous casting becomes commercial are touched on. These include mold design, protection against oxidation, a complete study of the properties of liquid metal and automation of the process. The necessity for carefully coordinating research is stressed. (Abstract *J.I.S.I.*, 1958, June, p. 181b.)

1640 CERNOCH, S., et al.: "Research into the Flow Pattern of Combustion Gases in, and the Heating of, Soaking Pits by Means of Models," *Hutnik* (Prague), 1960, (1), pp. 21–24. The flow patterns of combustion gases in models of two types of present-day soaking pits are compared, and the effect of the type of burners on the fuel consumption and the output of the furnace is considered. The greater outputs of the four-burner design are explained. (Author's summary.)

1689 MAKELT, H.: "Graphical Method for Determining Forces and Power Requirements in Drawing Bars and Tubes," *Industrie-Anzeiger*, 1959, May 19, pp. 28–31. The graphical method described permits a ready calculation of data in respect of forces and power requirements both for simple and multiple drawing processes. These data are sufficiently accurate for practical purposes and have been confirmed by experiments on draw benches. (Author's summary.)

1384 PLYATSKII, V. M.: "Processes of Forming Metal Under Pressure in the Liquid and Plastic State and Their Development," *Lit. Proizv.*, 1956, (6), pp. 7–11. The various pressure casting and forming methods are discussed from the aspects of product quality, surface finish and metal economy. The prospects of their further development are considered. (Abstract *J.I.S.I.*, 1957, Dec., p. 356.)

1702 FORESI, M., and G. MASSOBRIO: "Progress in the Application of Oxygen in the Open-Hearth Furnace," *Met. Ital.*, 1959, July, pp. 257–273. Developments in the use of oxygen in the Martin furnaces of the Cornigliano Co. are described. Tests are described concerning the intensive use of oxygen in a furnace with a basic roof, giving the analyses and results obtained. (Author's summary.)

# Stretch-Reducing Operations
## at Colorado Fuel and Iron's Seamless Tube Mill

C. C. CRAWFORD
Superintendent, Seamless Mill
The Colorado Fuel and Iron Corp.
Pueblo, Colo.

*This mill has produced a wide product range from a few entering shell diameters—thus reducing the load on the seamless mill and permitting a large increase in production rates.*

IN 1953 the Colorado Fuel and Iron Corp. placed in production a seamless tube mill for the production of oil well casing and tubing. This installation, the only seamless mill west of the Mississippi river, is situated in the heart of the oil producing area of the U. S., at the Pueblo, Colorado, plant. The main concentration of seamless production is located in the Pittsburgh, Cleveland, Youngstown and Chicago areas.

Original scheduling called for the production of all sizes which included 2⅜ through 9⅝-in. diameter material in single lengths from some six billet sizes ranging from 3½ to 8 3/16 in. This is an extremely wide range of pipe sizes for efficient production. Most plants in the U. S. that cover such a wide range of sizes are equipped with two or more mills. Small fast mills are built for smaller sizes and usually cover sizes from 5½ in. down, while the larger mills produce from 5½ in. up. The mill at Pueblo is somewhat larger than these small mills and somewhat smaller than the large mills.

In the design of most mill operating equipment, maximum efficiency is usually gained at one size and efficiency is reduced for sizes above or below the optimum. It appears that the seamless mill at Pueblo is most efficient when producing 7-in. diameter pipe with 5½ and 7⅝-in. material a close second. However, it should be noted that the demand for 7-in. pipe has been relatively small, with 5½-in. pipe in the greatest demand followed by the tubing sizes 2⅜ and 2⅞ in. then 4½-in. casing and the larger sizes 7⅝, 8⅝ and 9⅝ in.

The seamless mill at Pueblo was designed along conventional lines, consisting of a billet heating furnace, two piercing mills (one for the initial piercing of the solid billet, the second for wall reduction), an automatic plug mill and two reelers. In order to accomplish the final sizing of the product, two mills were installed to process shells from the reelers, a 14-stand reducing mill for sizing 2⅜ and 2⅞-in. pipe, prior to which reheating was required, and a 7-stand sizing mill for 4½ through 9⅝-in. pipe.

Mill performance on sizes 5½ through 9⅝ in. were satisfactory; however, the smaller tubing 2⅜ and 2⅞ in. representing some 20 per cent of the tonnage required in excess of 45 per cent of mill time. Not only was production low but losses during processing were high and the product varied considerably in dimensions, especially the wall thickness which tended to be on the heavy side. This variation caused considerable difficulties in subsequent operations and a substantial loss in yield.

In order to overcome these conditions, a stretch-reducing mill shown during construction in Figure 1 was installed to replace the 14-stand reducing mill. The stretch mill offered the means with a comparatively small capital expenditure to produce the smaller sizes without a loss in efficiency.

The great advantage of the stretch-reducing mill is that smaller sizes can be produced from larger billets, in multiple lengths and in combination with other sizes where a similar billet diameter and/or shell is used. Production rates have been increased substantially, actually, some six fold for 2⅜ in. and three fold for 2⅞-in. tubing. Since the demand for 4½-in. casing is

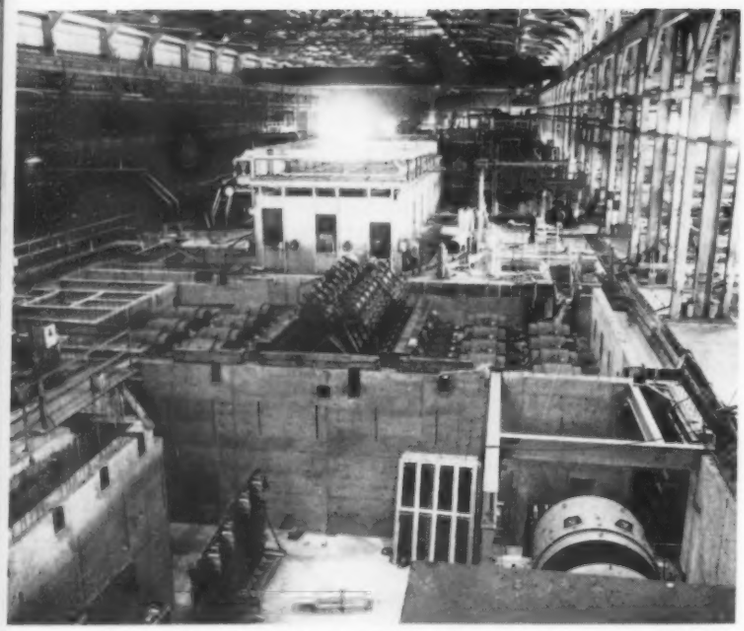


**Figure 1 — Individual motors for each stand are installed in two double rows to permit the smallest possible spacings between stands.**

rapidly increasing, it is also being processed through this unit. Through the installation of this mill, the number of billet sizes required has been reduced from six to three and delays for the size changes have been materially lowered. Also of special interest is the improved quality of the finished product, especially in dimensional properties.

The stretch-reducing mill was patented in the U. S. in 1932 and various mills were installed in this country in connection with butt weld, electric weld and seamless mills in the 1940's. However, it was not until 1955 that a stretch-reducing mill was installed to process shells produced on a seamless mill using reelers. Since that time, three such installations have been made.

In general, mills installed prior to 1955 were designed to produce sizes from 2⅞-in. diameter tubing down to ¾ or even ½ in. and the maximum entering shells were on the order of 5-in. diameter or smaller. The mill at Pueblo was designed for a maximum entering shell of 7⅝ in.

New facilities for this installation in addition to the stretch-reducing mill include: a reheating furnace; handling tables for receiving, positioning and parting of the finished tubing; a cooling table; and an electrical control room. Fortunately it was possible to install this new equipment without relocating any of the existing units, except for the removal of the 14-stand reducing mill nor was it necessary to make any additions to the building. Consequently, this installation was made without shutting down the seamless mill, although only the larger sizes could be produced during the construction period.

The hot shells from the reelers are conveyed to a chain type transfer table which moves them to the roller inlet conveyor of the stretch-reducing mill reheat furnace, see Figure 2.

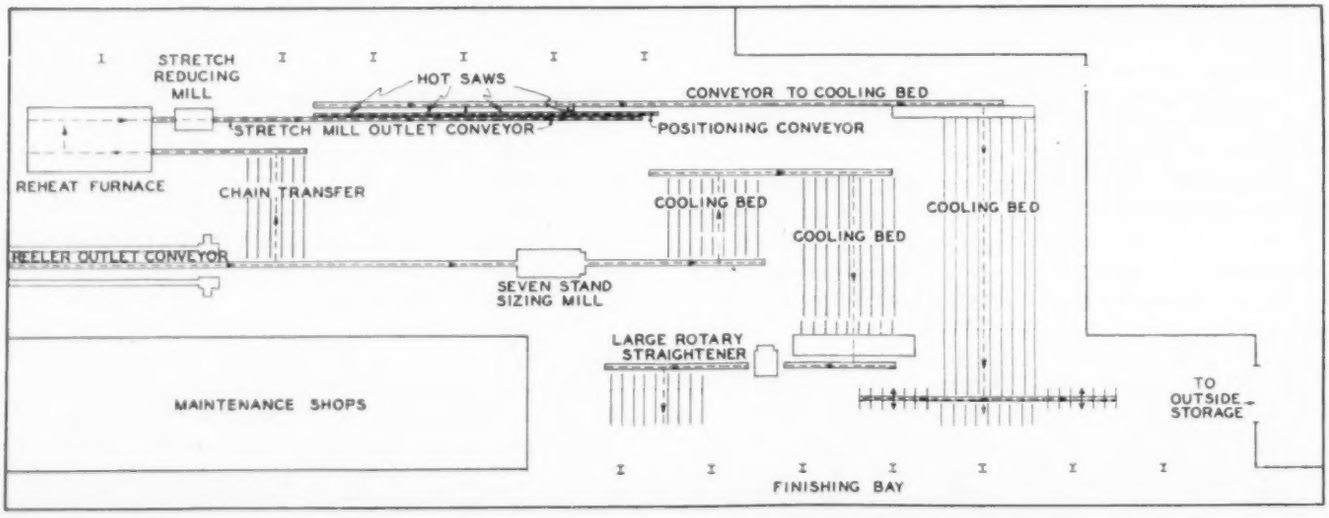
The gas-fired reheat furnace is of the roll down type with over-all dimensions of 56 x 19½ ft. Alloy conveyor rollers, skids and kick-outs which are employed throughout the inside of the furnace are not water cooled and function at furnace temperature (1800 F). Shells must be uniformally heated for good stretch-reducing operations, and water-cooled skids tend to leave cold spots on the tube. Any variations in temperatures of the shell will result in variation in wall thickness of the finished tubing. In the extreme case the tube will part during the stretching operation. Strongly reducing atmospheres are maintained in the furnace.

The shell is charged from the end of the furnace and upon contact with a bumper inside the furnace is kicked on to skids, which are sloped toward the outlet side. The tube is held in the furnace by stops mounted parallel to the outlet conveyor. After several shells have been charged and upon reaching the proper temperature, the shell is lifted over the stops to the discharge conveyor inside the furnace.

Normally, some 20 shells, up to 46-ft long, are kept in the furnace so that a continuous operation can be maintained. The furnace is rated at 140 shells per hr.

The mill (Figure 3) located only nine ft from the reheat furnace is a 16-stand mill divided into two groups of different diameter rolls. The first seven stands employ 14⅝-in. diameter rolls on 15-in. centers while the last nine use 12-in. rolls on 12½-in. centers. The

**Figure 2 — Partial layout of the pipe mill shows the placement of the stretch mill in relation to the reeler outlet.**



roll stands are set at right angles to one another and at 45 degrees to the horizontal. It will be noted that spacing is held to the absolute minimum. This is essential in a stretch-reducing mill since crop losses are largely determined by stand spacing.

Each stand is powered by a 200-hp, d-c variable-speed motor with a maximum of 1700 and a minimum of 850 rpm. Electrical controls are such that with normally fluctuating loads the motor rpm is held to 0.25 percent accuracy. Of course under high impact loads the drop will be somewhat higher; however, due to the regulating system recovery is very rapid. High impact loads are encountered during initial loading and may reach as high as 500 per cent of load rating for the motors. The feature of accurate rpm control and fast recovery is highly desirable, since crop losses and wall reductions are materially affected by variation in rpm.

Other features of the mill include the electrical control room which is located in a basement area adjacent to the mill. This control room houses the 1200-kva motor-generator set and switchgear. Dial gages and recording equipment for both amp and rpm readings are provided for each of the 16 stands.

Upon leaving the stretch mill, the tube which may be up to 140-ft long is kicked off the outlet rollers to a conveyor for positioning prior to cutting. After positioning the tube is lifted in one unit, by a series of star wheels and is carried through the dividing saws. The cut-to-length unit is equipped with four saws, see Figure 4. Three of the saws may be used to obtain up to four lengths, while the fourth saw is used to remove a portion of the trailing end crop. It has been our practice to leave the full crop on the front of the tube.

In order to facilitate handling and processing, the middle cuts, entering end cuts and trailing end cuts are sorted into separate cradles as they leave the cooling bed.

The main principle underlying the stretch-reducing process is that with the introduction of tension in the tube, the wall as well as the diameter may be reduced. In order to develop this tension it is necessary to take large diameter reductions. In conventional sizing mills such as the old 14-stand reducing mill, where little or no tension exists in the tube, diameter reductions are limited to 3 to 3½ per cent per stand. Higher reductions will result in wall and inside surface distortion. Also in these mills there is a noticeable increase in wall thickness. Stretch reducing overcomes this tendency for wall thickening and in fact reduces the wall below that of the entering shell.

To obtain the tension necessary to reduce the wall, sufficient diameter reductions must be made so the tube is firmly gripped by the rolls. In order to obtain this reduction it is necessary to start with large entering shells. In the old reducing mill shells of 3⅝-in. diameter were reduced to 2⅜-in. diameter in 14 stands with an increase in wall of about 0.010 in., while with the stretch-reducing mill the entering shell for this same finished size is 6-in. diameter and the wall is reduced from 0.250 to 0.190 in. in 16 stands. In the 14-stand reducing mill one 32-ft length was produced while four lengths are obtained from the stretch mill.

In setting practices for the stretch-reducing mill it is first necessary to select the entering shell diameter and wall. Maximum theoretical wall reductions for a given diameter reduction have been calculated for the mill; however, those used in actual practice are somewhat less than these maximums. It was possible to select shells that could be produced from billet diameters that fit into the rolling schedules for sizes currently in demand. By making the selections in this manner mill downtime due to equipment changes was held to a

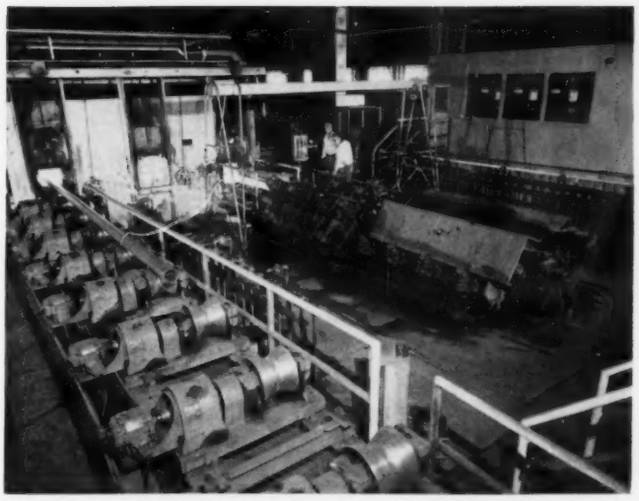


**Figure 3 — Shells are discharged from the furnace directly into the entry end of the stretch-reducing mill.**

**Figure 4 — The tube is cut into the desired lengths by hot saws and part of the trailing end crop is removed.**

**Figure 5 — Controls for the stretch-reducing mill are housed in a modern air-conditioned pulpit.**

minimum. Normally to change from one size to another where a different billet diameter is used, in excess of eight hr of mill downtime is experienced.

After selecting the diameter and wall of the entering shell, the next step is to determine basic speed. Basic speed may be defined as the tension necessary to maintain wall through the mill, i.e., the entering and leaving wall are the same. In order to develop this tension, roll speeds are designed so that the tube is pulling on the preceding stand. For 2⅞-in. tubing with a 0.217-in. wall, a shell of 6-in. diameter with a 0.270-in. wall was selected. A convenient method and the one which was used to determine basic speed is to first calculate the roll speed which is imparted to the shell so that the pitch line speeds multiplied by the tube cross sectional areas, assuming the same entering wall thickness in all stands, is a constant. The roll rpm are then multiplied by an overspeed factor which is required for the tube to have a constant wall.

For tubes with an entering D/t (diameter/wall thickness) ratio of about 20, the overspeed between stands is usually 1.0075, i.e., 0.75 per cent. The speeds thus obtained for all the stands are called basic speed.

After basic speed has once been determined, it becomes a matter of trial and error to determine an overspeed pattern over and above the basic speed that will produce the desired wall reduction. These overspeed patterns are first calculated and then tried on the mill. Since the motors are variable speed, a multitude of patterns can be developed and for some sizes a great number of patterns were tried before the desired results were obtained.

It must be realized these overspeeds are fictitious since the tube in the mill undergoes a wall reduction. Actual overspeeds computed with actual thicknesses in the stands would range between two and four per cent. The above outline method is used only for convenience to speed up calculations.

A typical overspeed pattern expressed in percentage for 2⅞-in. tubing would be: stand No. 1, zero per cent; No. 2, four per cent; No. 4, through 11, six per cent for each stand; No. 12 stand, four per cent; No. 13, zero per cent; and No. 14, the last stand for this size, zero per cent. It should be noted that this overspeed is accumulative as shown in Table I.

As might be expected there is a considerable slippage, that is the peripheral speed of the rolls is greater than the tube speed. The amount of slippage increases with each stand from the middle towards the outlet end. In some cases where the D/t ratio is high and it is necessary to obtain maximum wall reductions, slippage may be as high as 35 per cent for the last stands.

The practices for each size and wall thickness produced on the stretch mill offer different problems and require different practices. Overspeed patterns, diameter reduction, etc., must be designed for each product.

The practice for 2⅜ x 0.190-in. wall tubing calls for an entering shell of 6-in. diameter by 0.250-in. wall, 42-ft long produced from a 5½-in. billet. This shell is stretch reduced to produce four 32 ft-3-in. lengths plus crops for a total of 138 ft. All 16 stands are used for this size. Total diameter reduction is 60.4 per cent with the maximum reduction in any one stand of 7.5 per cent. The wall is reduced from 0.250 to 0.190 in. or 24 per cent.

**TABLE I**
**Typical roll Rpm for 2⅞-In. Tubing**

| Stand | Base speed | Basic speed | Overspeed Pattern, 6 per cent | Per cent overspeed per stand |
|---|---|---|---|---|
| 1 | 75.0 | 75 | 75 | 0 |
| 2 | 76.5 | 77.1 | 78 | 2 |
| 3 | 78.6 | 79.9 | 85 | 4 |
| 4 | 83.0 | 85.0 | 95 | 6 |
| 5 | 87.8 | 90.6 | 107 | 6 |
| 6 | 93.2 | 96.8 | 122 | 6 |
| 7 | 99.1 | 103.7 | 139 | 6 |
| 8 | 135.5 | 142.8 | 203 | 6 |
| 9 | 144.0 | 152.9 | 230 | 6 |
| 10 | 153.5 | 164.2 | 261 | 6 |
| 11 | 159.3 | 171.8 | 289 | 6 |
| 12 | 164.4 | 178.7 | 311 | 6 |
| 13 | 164.9 | 180.5 | 313 | 0 |
| 14 | 164.9 | 180.5 | 313 | 0 |

The 2⅞-in. diameter by 0.217-in. wall tubing is made from a 6-in. diameter by 0.270-in. wall shell, 41-ft long. Here again the shell is produced from a 5½-in. billet. This shell is stretch reduced to produce three lengths 32 ft-3-in. long plus crops for a total of 104 ft-9 in. Total diameter reduction is 52.1 per cent with the maximum in any one stand of 7.5 per cent. The wall is reduced from 0.270 to 0.217 in. or a wall reduction of 19.6 per cent. Only 14 stands are used for this size.

These two sizes form a large portion of the tonnage produced through the stretch mill and are produced from the 5½-in. diameter billet and the 6-in. shell, the same as 5½-in. casing. These sizes are scheduled to roll during runs of 5½-in. casing, since no changes of mill equipment are necessary. Time required to change from 5½ to 2⅜ or 2⅞ in. and vise versa, is negligible.

Other sizes produced from a 6-in. shell are 3.063 and 3.668-in. diameter material which are used for 2⅜ and 2⅞-in. couplings, respectively. The entering wall for 3.063-in. material is 0.471 in. and the finished wall is 0.414 in. for a wall reduction of 12.1 per cent. The entering wall for 3.668-in. diameter material is 0.540 in. and the finished wall is 0.479 in. for a wall reduction of 11.2 per cent. Just 13 stands are used for 3.063-in. material and 11 stands for the 3.668-in. material.

The largest finished size that is presently stretch reduced is 4½-in. casing, and it is produced in wall thicknesses of 0.205 and 0.250 in. It is being reduced from a 7-in. shell and experiments are planned for a 7⅝-in. diameter shell.

In stretch reducing 4½-in. pipe, wall reductions are not as great as the other sizes discussed. This can be explained by the smaller diameter reductions and the lighter entering walls in relation to the diameter. Shells with a higher D/t tend to thicken to a greater extent than heavier wall material. Furthermore, the shell is not gripped as tightly by the rolls.

For 4½ x 0.205-in. casing, the entering shell is 7-in. diameter by 0.215-in. wall for an over-all diameter reduction of 35.7 per cent and wall reduction of 4.1 per cent.

The 4½ x 0.250-in. casing is produced from the same diameter shell; however, the entering wall is 0.265 in. for a wall reduction of 5.7 per cent. Only 12 stands of rolls are used for 4½-in. casing. Two 33 ft-2-in. lengths plus crops are obtained for both wall thicknesses.

The 7-in. diameter shell is produced from a 6½-in.

diameter billet, the same as for 7-in. casing. To change from 4½ to 7-in. casing requires about 30 min, since the shell diameter for 7 in. is 7⅝ in. while that for 4½ in. is 7 in. and a groove change at the plug mill is required.

One disadvantage of the stretch mill is the heavy crop that must be taken because of the heavy wall at the ends of the tube; however, with the production of multiple lengths the percentage of loss is reduced. The reason for the tube thickening at the ends is as follows. Since the wall of the tube is being reduced only when it is subjected to full tension and this tension is developed only when the tube is engaged in several sets of rolls, it follows that the wall will be extremely heavy at the ends and will be progressively lighter, until nominal wall is reached. The amount of crop required depends upon diameter reduction, wall reduction and roll spacing. The greater any of these factors are the longer the crop will be.

The stretch-reducing mill at the Pueblo plant has proved to be a highly successful addition. The full range of sizes of 2⅜ through 9⅝-in. pipe is produced from three billet sizes, 5½, 6½ and 8 in. This is desirable from many angles, both at the seamless mill as well as at the mills rolling these rounds. Production rates for the smaller sizes have been increased substantially downtime due to size changes has been materially reduced, the dimensional properties of the product have been greatly improved and the over-all quality of the finished product is better than experienced with the 14-stand mill.

# Discussion


**PRESENTED BY**

**L. R. FRANKLIN. Assistant Superintendent E. W. Pipe Mills, Lone Star Steel Co., Dallas, Texas**

**C. C. CRAWFORD, Superintendent Seamless Mill, The Colorado Fuel and Iron Corp., Pueblo, Colo.**

**D. HANCKE, Vice President—Sales, Mannesmann-Meer, Inc., Youngstown, Ohio**

**A. S. URANO, Industrial Engineering Operation General Electric Co., Schenectady, N. Y.**

**DR. ING. FRIEDRICH KOCKS, President, Friedrich Kocks Duesseldorf, Duesseldorf, Germany, and ASTOR L. THURMAN, President, Lombard Manufacturing Co., Youngstown, Ohio**


**L. R. Franklin:** Lone Star Steel Co. takes great pride in its stretch-reducing mill, which began operations on January 7, 1958. The stretch mill is operated in conjunction with an electric weld tube mill which offers quite a contrast insofar as operating problems are concerned to the mill described in the author's paper.

Among the operators of the various types of stretch-reducing mills, there could be limitless discussions on their relative advantages and disadvantages. Of primary importance is the fact that with the addition of their stretch-reduction mill, Colorado Fuel and Iron Corp. has cut the required number of billet sizes in half, reduced downtime and greatly increased their tubing and small casing production.

To what extent is crop loss reduced by using smaller rolls in the last nine stands of your mill? Based on experience at Lone Star Steel Co., it is believed that the principal loss is determined by the stand spacing in the entry stands of the mill.

With regard to machining and scheduling of rolls, we machine our rolls in the housing, cutting all three rolls simultaneously and step the rolls back from the last pass to the first pass. In view of the different mill design, it would be interesting to know how your operation differs from this.

Since roll life is of primary concern to stretch mill operators, could you give us some idea of your roll life experience?

In view of the considerable amount of slippage which you have indicated occurs in your mill, how much gage variation or squaring of the I.D. is experienced in the various finished sizes? Is this variation greater in the larger finished sizes where your percentage of O.D. and wall reduction is smaller?

**C. C. Crawford:** The closer spacing of the last nine stands of the mill does aid in reducing crop loss. Certainly the wall thickening that does occur in the stretch-reducing mills is more apparent in the entry stands; however, it must be remembered that the tube at the entry end is under considerably less tension than in later stands and therefore there is less wall reduction. In addition, there is a greater tendency for wall thickening at the entry stands because of the higher D/t ratios. (The higher the D/t ratio, the greater percentage of wall thickening there will be.)

In stretch reducing enough tension must be applied to overcome this tendency to thicken as well as reduce wall below that of the entering wall. The wall thickness of tubes that are stretch reduced are, of course, heavy at the extreme ends and become lighter from the end until a uniform wall is reached. Now if the tube is cropped where uniform wall is obtained then the center distance between entry stands would be the determining factor. However, this crop loss is less if the crop is taken where the wall thickness is in tolerance. The closer spacing of the last nine stands does reduce the crop loss since the point at which the tube is in tolerance is closer to the end of the tube than when stand spacing is greater.

The practice followed for scheduling of roll dressings is similar to that used at Lone Star, i.e., the rolls are stepped back from the last pass to the first pass for the different roll diameters. It is necessary to remove each roll individually and they are then dressed separately.

Our experience with roll life indicates that a greater roll life can be expected with the small sizes. Normal roll life for 2⅜-in. J grade tubing is on the order of 1,300,000 ft. For 4½-in. O.D. by 0.205-in. wall the roll wear is greater. This is due to the high overspeeds between stands called for by the high D/t ratio to obtain the required wall reduction.

A small gage variation on the order of 0.003 or 0.004 in. has been noted which is probably due to slippage; however, it has not detrimentally affected the quality of product. No squaring of the I.D. has been noted except at the ends of very heavy wall material.

It has not been necessary to take additional crop because of this condition.

**D. Hancke:** It might be interesting to have some additional information on the relation between the 16 drive motors of the stretch-reducing mill, each with a capacity of 200 hp, and the 1200-kva motor-generator set, particularly in view of experienced impact loads on the individual motors of up to 500 per cent. Do you have figures on the total power actually supplied by the motor-generator set, for instance for the reduction from 6 to 2⅜-in. tubing in 16 stands?

Another point of interest is the determination of overspeeds for each roll stand to obtain the necessary tension in the roll pass and the slippage resulting from this. Your figure of up to 35 per cent slippage for the last stands seems to indicate that these rolls, even at their minimum diameter at the bottom of the roll groove, run considerably faster than the tube.

There are various schools of thought on this subject. One group maintains that the actual transport diameter on a stretch-reducing mill roll, that is when rolling under tension, should be the bottom groove diameter of the roll, while others believe that the transport diameter should be in the vicinity of the median point of the roll groove contour. In your many trials to find the roll speeds best suitable for your schedules, you have surely gained considerable experience concerning the actual location of the transport diameter, or in other words, the point of no slippage between roll and tube, and your comments should be very much appreciated by all reducing mill operators.

**C. C. Crawford:** As Mr. Hancke points out, there are several schools of thought as to where the actual transport diameter should be with relationship to the groove diameter. Our attitude in general, has been that it makes little difference where this transport diameter is provided a satisfactory tube is produced and full consideration is given to roll life and other economic factors.

In most instances our roll speeds are such that the transport diameter falls somewhere between the bottom of the groove and the median point with the greater majority near the bottom. Although as pointed out, in some cases, the transport diameter may be below the bottom of the groove. We have done some experimental work, though somewhat inconclusive, that indicates that when the transport point is above the median point the rolls are inclined to wear rapidly and, as long as the tube is not damaged, satisfactory results can be obtained even with the transport point well below the bottom of the groove.

**A. S. Urano:** A mill is valued for its ability to produce a satisfactory product with a minimum of scrap. The function of a stretch-reducing mill is to produce tubing with required O.D. and uniform wall thickness within specified tolerances and with minimum crop loss.

Both the mechanical and electrical systems affect the meeting of these objectives.

Since tension between stands cannot be applied until at least two sets of rolls are working on the tube, the front end of the tube will first be subjected to compressive forces and then to nonuniform tensions. This is because the entering portion of the tube is not subjected to the full amount of tension developed through each roll stand in the entire mill. Therefore, the portion of the entering tube between stands No. 1 and 2 will be off gage.

Normal tensions are not established until a stable speed relationship is reached between stands No. 1 and 2. For example, as the front end of the tube proceeds through each successive stand, a transient speed disturbance will occur due to each stand motor loading which will upset the stands speed relationships and therefore tensions between stands. These changes in speed, as they occur, are reflected back throughout the mill to changes in tension between stands No. 1 and 2. The effect of these speed disturbances on the tension between stands No. 1 and 2 will be a diminishing one as the tube proceeds through the mill. Therefore, theoretically absolutely uniform wall will not be produced until the tube is in all stands at the same time.

The electrical disturbances which increase the length of off-gage tube at the tail end can also be described in a similar manner. In order, therefore, to minimize the tension variations and the off-gage tube, it is necessary to provide stand drive speed characteristics with a minimum impact speed drop and a fast recovery time. These characteristics will minimize the tension fluctuations and keep the wall thickness within acceptable tolerances. It is also important to maintain stand speed relationships regardless of stand loading. An operator should only go through the time-consuming job of setting up each stand speed once for each rolling schedule.

The electric drive system is designed for low impact speed drop and fast transient speed recovery. To achieve this performance individual stand driving motors with high inertias, low inductance and low armature resistance are used. High response speed regulators quickly perceive the impact speed drop and apply large amounts of forcing to obtain the necessary fast speed recovery. Preselected speed is also accurately maintained permitting the operator to concentrate on production and quality considerations.

**Dr. Ing. Friedrich Kocks and Astor L. Thurman:** Some of the problems outlined by the author in setting up and operating this mill have been simplified by a concept of stretch reducing which is new to the U. S., but which has been widely applied in other parts of the world. It should be of interest to members of the AISE to consider this approach in comparison to the mill the author has described. Many stretch-reducing mills had been installed in Europe and on other continents as early as 1951, some of these have been a part of a complete pipe or tube mill, others have been individual units. Because of the nature of the production pattern in these locations, every one of these installations has had to handle a much wider range of products than the mill the author has described. Conditions outside the U. S. do not allow the use of a stretch-reducing mill for production of only a few finished pipe or tube sizes. A good example is the following mill.

With a maximum entering size of approximately 6 in. this mill will produce all commercial sizes down to 1-in. pipe; in addition, with a second series of stands and a smaller entering diameter, it will produce down to ½-in. pipe. With the requirement for such a wide production pattern, generally for small quantities of any given size, the design of this mill must be such that

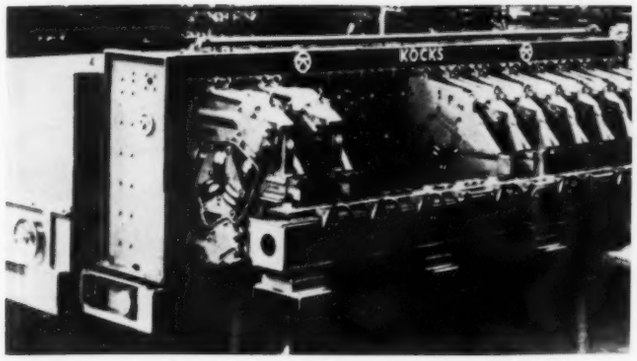


**Figure 6 — With an entering shell diameter of 6 in., the initial roll stands have 14.97-in. diameter rolls and a stand-to-stand center distance of 13.40 in.**

it is easy to change size in the shortest possible time.

The yield of this mill is generally comparable with the output of the mill the author has described. The entering pipe speed is variable between approximately 100 and 200 fpm. The top output speed will be about 1000 fpm. With all entering shell diameters the mill will produce at furnace capacity, which is 22 tons per hr.

Now to discuss a few of the differences in design of the two mills.

The diameter reduction in this mill is seven to eight per cent per roll pass, which is considered a favorable reduction with respect to the quality of the finished product. In reducing to 1-in. pipe from a 6-in. entering shell, a large number of stands are required; generally these mills have from 20 to 26 stands. This mill is not provided with individual drives for each roll stand, but with a group drive that provides for the flexibility previously indicated. Although other types of drives can readily be applied to this mill, all stretch-reducing mills so far delivered have been equipped with this drive. For a mill comparable to the one described by the author a 1075-hp, a-c motor and a 335-hp, d-c motor would supply power to the European mill for the same rolling schedules. The power of the two motors is transmitted separately through individual sets of differential gears provided for each 3-roll stand. Such a mill is illustrated by Figure 6. The roll pass is formed by three rolls, rigidly mounted in the stand with heavy bearings on each side of each roll. From stand to stand the rolls are set at half their parting angle, which in principle is the same as is done on the 2-roll mill stands at Colorado Fuel and Iron Corp. This mill design is such that the stands may be mounted in either of two positions to give additional flexibility in the rolling schedules.

In the stand differential gearing the output of the fixed speed shaft from the a-c motor (basic speed) and that of the variable speed shaft from the d-c motor (superimposed speed) are combined through the pinion stand to the three rolls of each stand. A series of basic speed values exists, these speed values being determined by the a-c motor and its connected gearing.

Figure 7 shows such a series of basic speeds and the resulting conditions for a tube with an entering wall thickness of 0.236 in., with the increasing speed values shown for each stand. From this graph it can be seen that with only the a-c motor running and the d-c motor locked at zero speed, a finished tube size with heavier wall is produced. If the tube being reduced is to have a thinner wall, it is only necessary to raise the series of speeds as a group by increasing the speed of the d-c motor. Thus, the speed of the d-c motor for a given series of a-c motor speed contributions determines the amount of wall reduction, as indicated by Figure 8.

In Figure 8 the tube O.D. is plotted against the wall thicknesses of both the entering and leaving tube, while the necessary speed variation of the d-c motor is indicated at the bottom of the graph. With the one starting shell wall of 0.236 in., all of the various tube walls within the cross-hatched field can be produced merely

**Figure 7 — Increasing the d-c motor speed changes the wall reduction of the entering shell.**

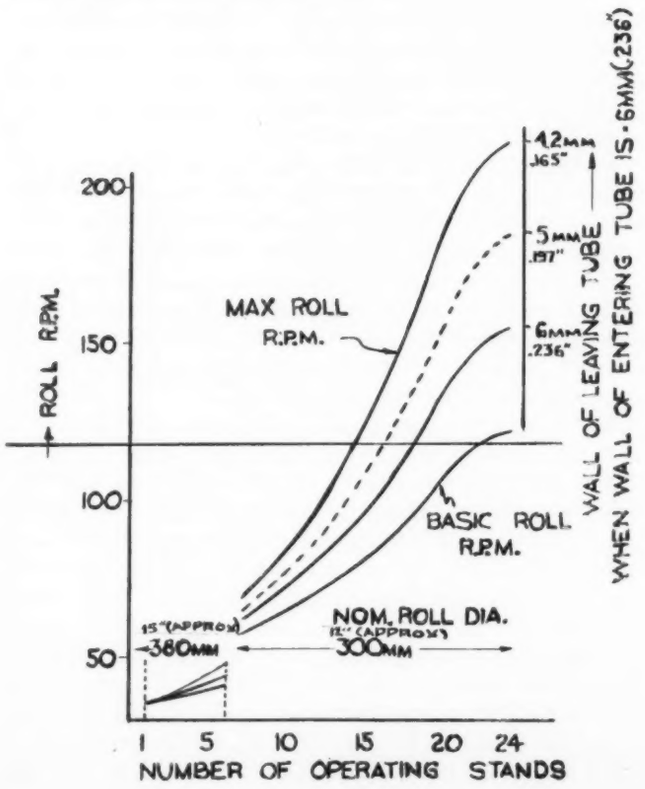
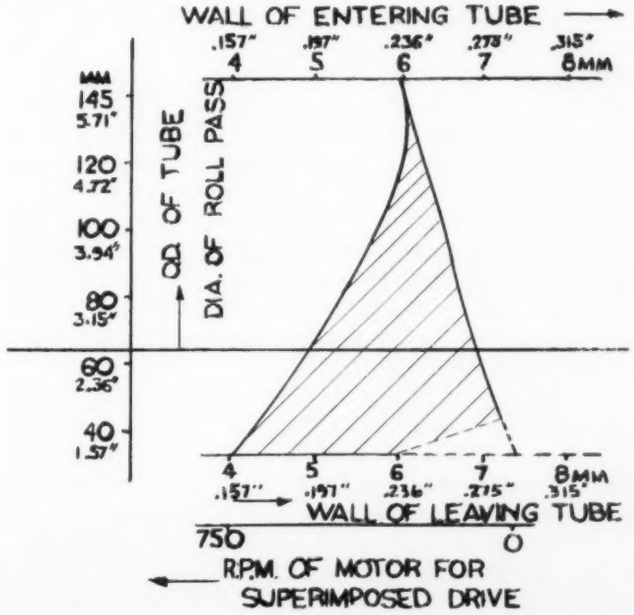



**Figure 8 — A single control adjustment permits wide changes in wall thickness of the finished tube.**



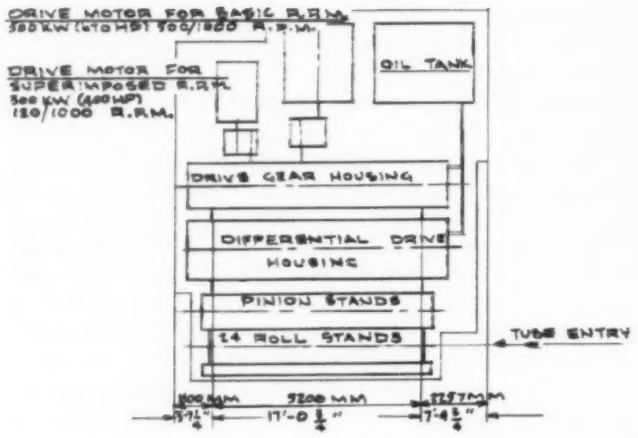



**Figure 9 — This type mill shown in plan view can be constructed with two d-c motors and is more compact than the individually driven roll stand mill.**

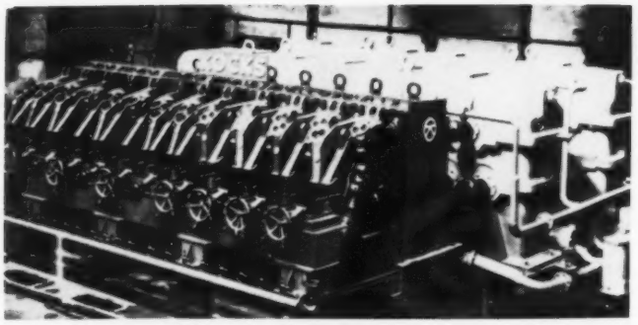


**Figure 10 — The differential gearing and the mill stand drive gears are provided with separate housings.**

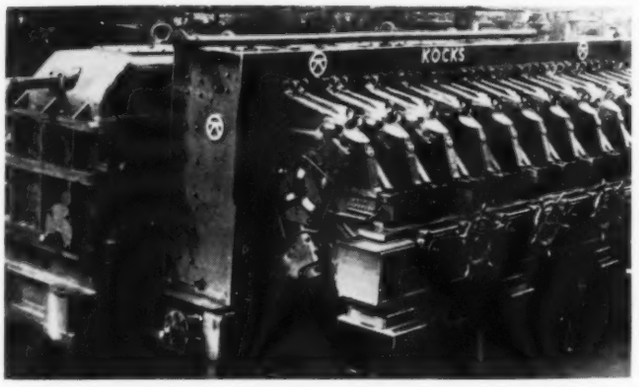



**Figure 11 — On smaller mills a common housing may be used for the differential gearing and the mill stand drive gears.**

by changing the speed of the d-c motor, this can be done from the operator's control desk without stopping the mill. The relationship between the additional speed contribution of the d-c motor and the wall reduction is calculated in the original mill layout and is checked in actual operation during the startup and running-in of a new mill.

Although this type mill does not have to be powered by this a-c motor, d-c motor differential drive combination, all our mills so far delivered have been equipped with this drive arrangement.

In addition to the lower installed horsepower on the mill to accomplish a given reduction and the simple method available for changing the wall reduction without interrupting the mill operation, one advantage is that a solidly geared mill is available which absorbs the impact load of the entering tube without the slightest change in stand speed. As has been mentioned before in the literature on this subject, this is one of the prime concerns in designing a stretch-reducing mill drive.

Another feature of the double motor approach is that the roll speeds available from the a-c and the d-c motors, can be designed very accurately in such a way that the combination of the two series of speeds will result in a series of stand speeds in which the material of the tube or pipe being rolled is subjected to an equal strain in all roll passes, with the exception of the entering and leaving stands, at up to a maximum of 70 to 80 per cent of the tensile strength. Maintenance of uniform stretch of the material achieves the big wall reduction.

This possibility for equal distribution of stretch compensates for the lack of individual stand speed adjustment. The mill operator eliminates the need for the trial and error approach in arriving at a rolling schedule for producing a given finished product from an entering shell.

The amount of possible wall reduction for any given tube depends primarily on two factors, the diameter reduction and the permissible longitudinal tension in the tube material. Besides this, all other conditions remaining the same, the curvature of roll pass formed by the three rolls provides for a greater tension between stands as compared to the 2-roll stand as has been proved in practical rolling experience. Normal wall reductions are $\frac{1}{4}$ to $\frac{1}{3}$ of the entering wall, depending upon the diameter reduction.

It is possible with this design to make a quick change from a small finished tube diameter to a larger outgoing tube. The later stands of the mill are removed and two new finishing stands of the desired dimensions are substituted. The first of these two stands has a slight pass ovality and makes a slight diameter reduction, but the last stand is concentric to round the tube. The surface speed of the rolls of the last stand is slightly higher than the pipe speed, and this imparts a smooth surface to the finished tube.

Figure 9 shows a floor plan for a 24-stand mill with two d-c motors; this is the mill mentioned in the early part of this discussion in which even the entering basic speed is variable from 100 to 200 fpm. The overall length of this mill is about 29 ft. Figure 10 is a picture of this mill; in this case the drive gearing is in a separate housing from the differential gearing. Figure 11 shows a smaller mill in which the drive and differential gearing are combined in one housing.

In comparing the scrap end losses of the 2-roll and the 3-roll mill, the comparison should be made based upon the same total diameter reduction and the same elongation. With the same diameter reduction per stand the same number of stands would be used which means that the main remaining factor would be the stand spacing. From the illustrations used note that this design with three rolls allows a closer stand spacing than a comparable 2-roll stand; thus, an accurate comparison of the two mills would likely result in a ratio of scrap end losses due to heavy walls which would be equal to the ratio of the roll stand spacing, which would favor this 3-roll mill. ▲

by F. A. WOODBURY, Consulting and Application Engineer, Westinghouse Electric Corp., Cleveland, Ohio

# Selecting Electrical Drives for Applications Under 500 HP

*Proper application of motor drives demands a wide knowledge of available features—plus the ability to determine the versatility required for the installation.*

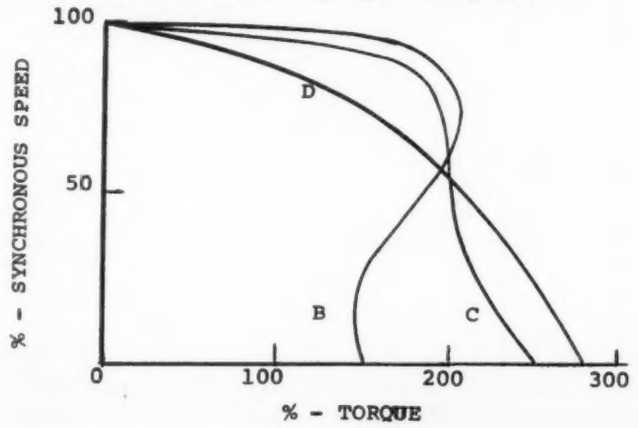
ELECTRIC motor drives are basic necessities in the iron and steel industry. Man-hours per ton go down in number as electrification increases, but there are many ways to electrify. Therefore, selection of a drive should be made with a knowledge of all that is available. One should know the characteristics of versatility of each drive. This versatility can be measured in the number of features available, such as range of speed adjustment, availability of jogging, tension control, regeneration, etc.

Some companies who have overlooked these fundamentals have embarrassingly discovered that what was acquired for a particular job was seriously inadequate.

The object here is to explore the field of adjustable speed drives and form categorical concepts of the relative versatility of these drives. Let the approach be to first examine each drive as to its applications and characteristics, and second, to compare each of them for versatility and efficiency.

*Squirrel cage motor*—Although the practical uses of the squirrel cage motor are well known, a speed torque curve for three of the NEMA classes is shown in Figure 1 for purposes of comparison. For continuous duty applications such as pumps and small motor-generator sets, the NEMA B motor with its medium starting torque, high pullout torque and low slip is considered efficient and low in first cost. The NEMA D motor, on the other hand, is considered most useful for intermittent service where high starting torques are desirable and where a decrease in efficiency at rated torque is not objectionable. Kickoff drives, pushers, shears and feedup drives on processing systems are some typical applications. The NEMA design C motor has a higher starting torque than the NEMA B, but it has less slip than the NEMA D and is therefore better suited to continuous service than the NEMA D because of higher efficiency. However, the rotor design used in the NEMA C motor prevents its use on applications requiring frequent reversals or long accelerating times.

**Figure 1 — Comparison of speed-torque curves of three NEMA classes indicate that the NEMA D is most useful in intermittent service requiring high starting torques.**




*Mechanical Adjustable speed drive*—The mechanical adjustable speed drive usually has a squirrel cage motor as its prime mover. Speed change is often accomplished by a change in diameter ratios of two pulleys. By bringing the two edges of one of the pulleys together the belt is forced out toward the periphery of the pulley, thus changing its effective pitch diameter. Such a drive coupling may be applied where a single output shaft will suffice to the mechanism or system. As is seen in the speed-torque curve of Figure 2, rated torque decreases with speed for anything above a one to one ratio on this type of drive.

*Eddy current coupling*—The electrical clutch is coupled to the load and is normally driven from a squirrel cage motor. Eddy currents are induced in the driven side of a coupling as a function of the coupling's d-c excitation. The result is a controlled output torque for the total drive.

The speed-torque curves, Figure 3, show maximum torque available for full excitation and 20 per cent excitation. The cross-hatched area is that area of opera-

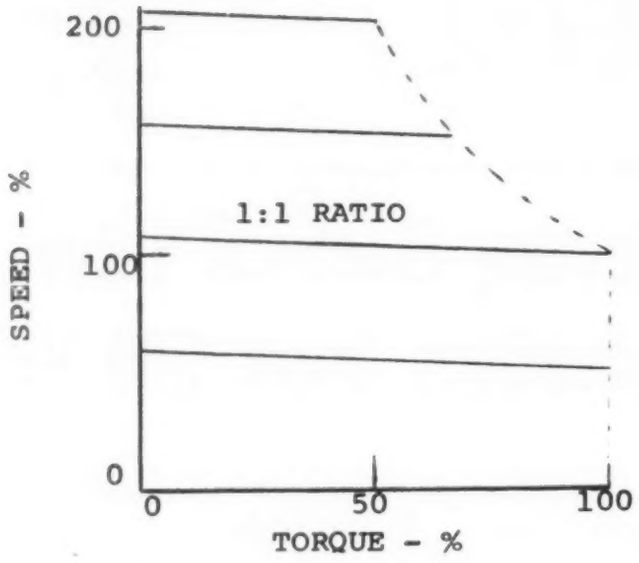



**Figure 2 — Adjustment of the mechanical drive causes a drop in torque at speeds above a one to one ratio.**

tion which must be restricted to intermittent duty. This coupling can provide both speed and tension regulation. It has been used on looping drives on annealing furnaces and other continuous process lines. It has been applied on a reversing single-stand cold mill supplying 300 hp. Since lost hp is a function of the product of slip and torque, the efficiency of this drive decreases as the slip increases.

*Hydraulic Drive*—The hydraulic drive is also generally driven by a squirrel cage motor. A variable displacement pump and a constant displacement motor produce relatively flat speed-torque curves, Figure 4. The maximum speed is confined to the limits of the prime mover.

*Wound-rotor motor*—The wound-rotor motor has essentially the same speed-torque curve, Figure 5, as the NEMA B motor when the secondary resistance is cut out. The drive is capable of operating at lower speeds on a continuous basis than a squirrel cage NEMA D.

Depending on the amount of resistance in the secondary, an operating characteristic may be selected in any one of the family of curves shown. These motors are particularly useful on large drives, where the starting current must be kept low as the drive comes up to speed under controlled torque. When a flywheel is associated with the drive, its inertia will permit shock loads to the system with a low degree of line disturbance, from which the wound-rotor drive may recover at a controlled rate. If used as an adjustable speed drive where speed must be kept constant for varying loads, the normal method of control will prove generally unsatisfactory. The efficiency of this type of drive at the lower speeds is obviously quite poor when considering that the product of slip and torque represents heat loss or wasted horsepower. The old Krämer system for adjustable speed wound-rotor drives utilized this otherwise wasted power, but required rather expensive additional rotating and control equipment.

However, there has recently been made available a drive which utilizes the principal of the Krämer system and conserves the power of the rotor voltage drop rather simply. Figure 6 indicates the basic arrangement

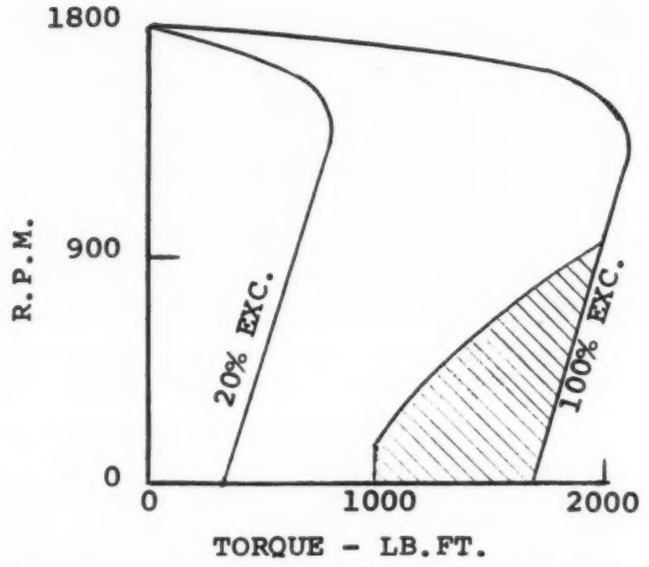



**Figure 3 — The eddy current clutch can provide a smooth engagement since the output torque is easily controlled.**

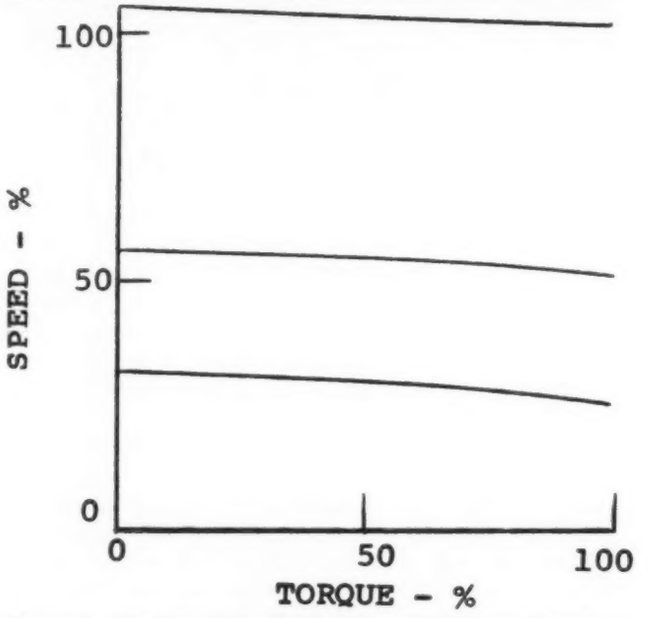
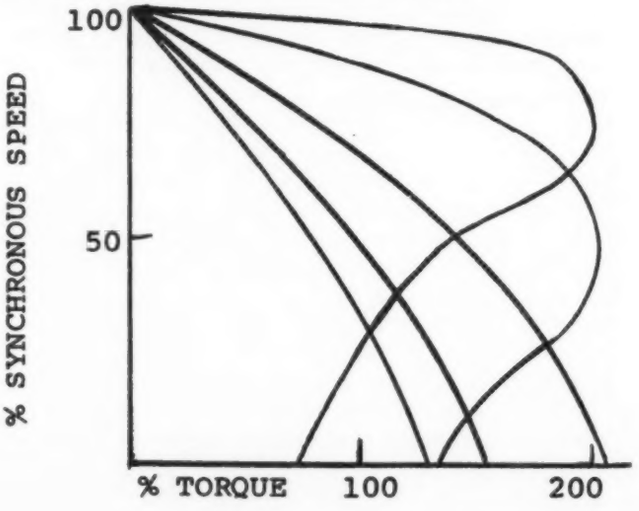



**Figure 4 — Final speed of the hydraulic constant displacement motor is related to the speed of the prime mover.**

**Figure 5 — The wound-rotor motor permits continuous operation at lower speeds since heat normally generated in the rotor is dissipated in external resistors.**



of the system. The secondary voltage at the wound rotor is applied through slip rectifiers to the armature of the d-c drive, thus transferring slip power from the wound-rotor motor back into its shaft. The advent of silicon rectifiers has made this type of drive feasible.

*Wound-rotor voltage vs system speed*—The straight line curve with a negative slope in Figure 7 is representative of the open circuit secondary voltage of the wound rotor. If a two to one speed range system is required then for the operating speed at $A^1$, the d-c motor must be selected for full field, full voltage operation at that particular speed, and the secondary voltage of the wound rotor must supply the necessary d-c machine armature voltage. The difference in voltage between $A^1$ and the wound-rotor secondary voltage curve is represented by the impedance drop in the a-c secondary circuit plus the IR drop in the d-c circuit. By weakening the field of the d-c motor to 50 per cent, the emf of the d-c machine decreases to point B. The wound-rotor secondary voltage will then be considerably higher than the voltage generated by the d-c machine and an increased armature current will flow, increasing the torques in both a-c and d-c machines. The added torque accelerates the drive to a speed where the voltages (including impedance drops) are again in balance at a constant speed. The efficiency of this drive remains high for all speeds through its speed range.

*Extreme speed-torque curves*—The two curves of Figure 8 represent the operating characteristics of a 125-hp, constant hp drive with two to one speed range. With no current on the field of the d-c motor, no torque is contributed by it and the curve appears much the same as a NEMA B squirrel cage motor. There is slightly more droop in the curve due to IR drop in the armature circuit, but the curve may be flattened by supplying a negative component of field flux to the d-c motor causing it to circulate just enough armature current to supply the losses for its own IR drop. The other extreme shows the speed-torque curve of the system with full field on the d-c components. Of particular interest is the 600 per cent starting torque for this drive which may actually be higher for constant horsepower drives with greater speed range. For high break-away torques and for high intermittent torques, this characteristic can prove very useful. However, if gearing and shafts are not sufficiently strong for this high torque and if the added torque is not needed, different methods of reduced voltage starting can be used. Also, the maximum torque at rated current is as would be expected for this constant hp drive in that the torque capacity must decrease at higher speeds.

*Variable frequency drives*—The variable frequency drive system as shown in Figure 9 has long been in use in the steel industry on applications such as conveyors or runout tables. In the past, the supply for this type of drive meant an a-c to d-c motor-generator set and another d-c to a-c motor-generator set to produce the variable frequency. The speed of a large number of small induction motors would vary according to the frequency of the synchronous generator which was a direct function of d-c drive motor speed. Although the system is being replaced in many instances by d-c motors powered from a common bus, consideration is still being given to its use for bar and rod mills where there are a large number of small conveyor motors which experience relatively continuous operation over no greater than three to one speed range. A loss of torque at speeds below one third rated is the basic

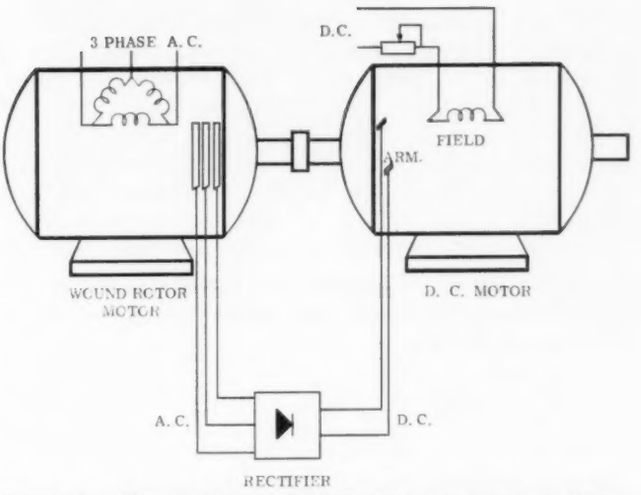



**Figure 6 — Use of silicon rectifiers has permitted modification of the Krämer system to eliminate the additional rotating and control equipment formerly required.**

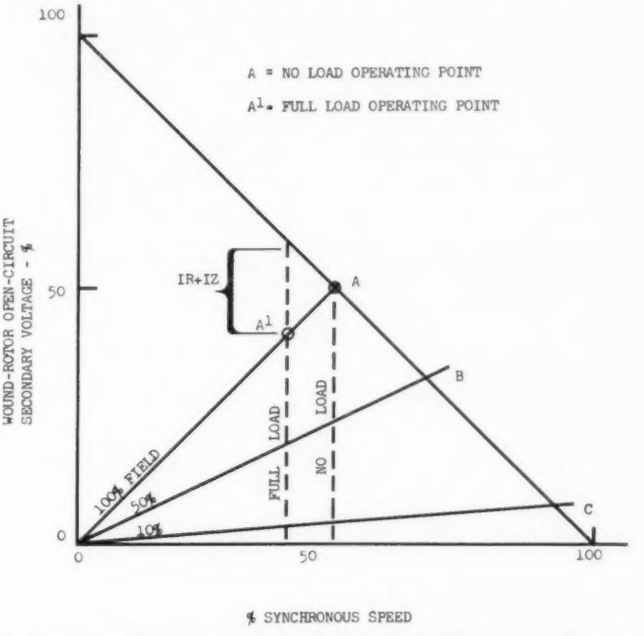



**Figure 7 — The power from the wound-rotor secondary is utilized in the d-c machine.**

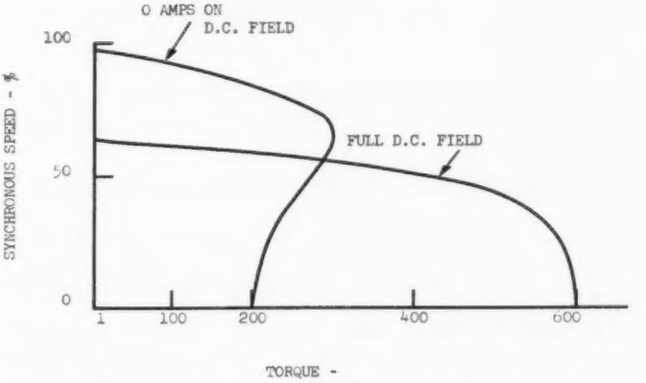



**Figure 8 — Extremely high starting torques can be supplied with full field excitation of the d-c motor.**

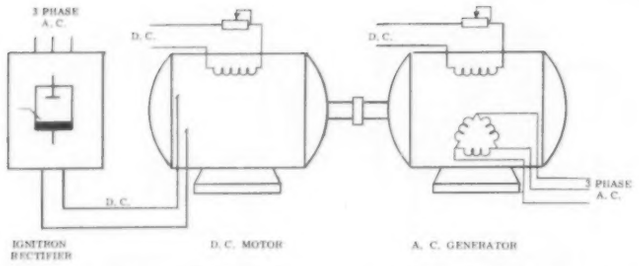



**Figure 9 — Use of a rectifier circuit has eliminated one of the two motor-generator sets formerly required for a variable frequency drive.**

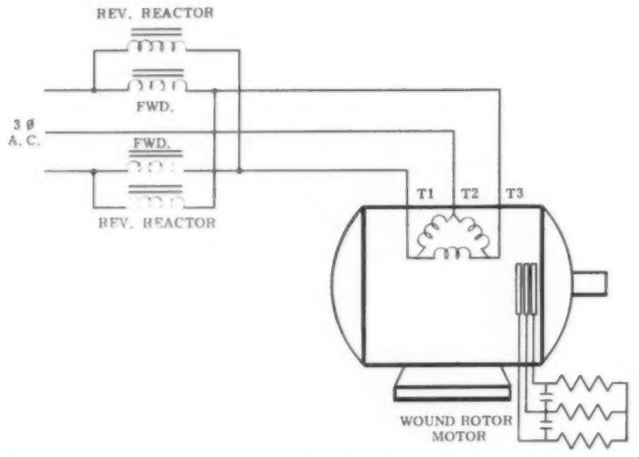



**Figure 10 — Reactors can be used to reverse, or vary the speed and torque of a wound-rotor motor.**

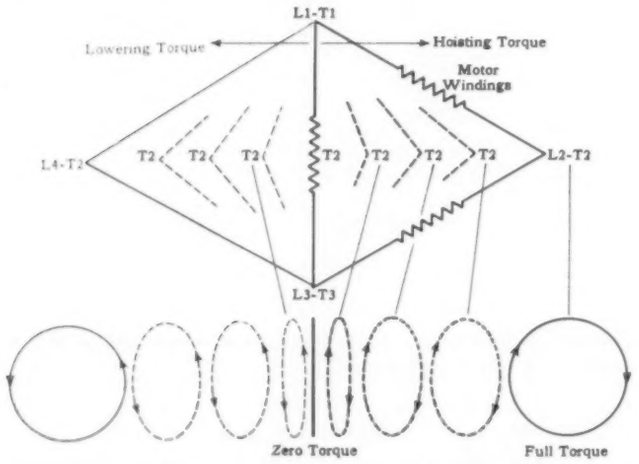



**Figure 11 — Reactor saturation control permits variation of torque from a positive maximum to a negative maximum.**

reason for the range limitation.

In 1958 a variable frequency conveyor system was installed in India where the main drives were supplied by power from ignitron rectifiers. Since the 57 squirrel cage motors powered from a 234/738-kva alternator represented a small percentage of the total power consumed by the rectifiers, regeneration was possible into the main drives. An equal-volts-per-cycle regulator was included to provide good speed control on the drives over the speed range.

*Reactor-controlled wound-rotor drive*—By using reactors in conjunction with secondary control for a wound-rotor drive, the torque and speed of the drive may be made to vary infinitely. Figure 10 illustrates how reactors may be placed ahead of an a-c induction motor to

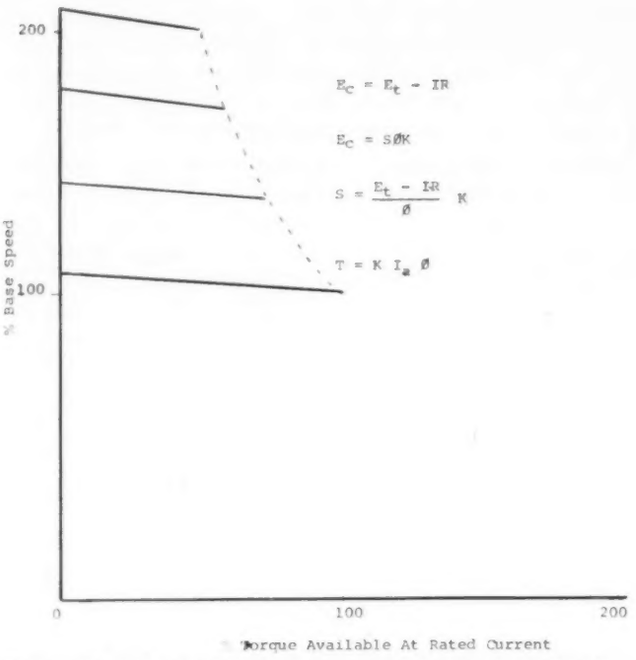



**Figure 12 — Controlling motor speed by field weakening presents the problem of reduced torque at the higher motor speeds.**

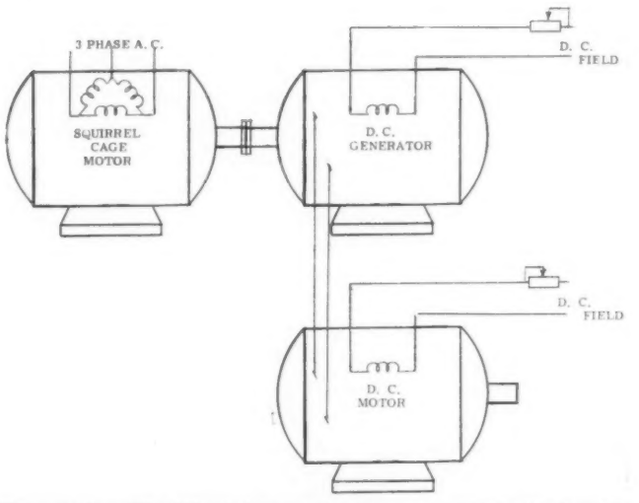



**Figure 13 — The Ward-Leonard system is applied both with and without motor field control. This control permits application of constant horsepower over a substantial range.**

provide reversing control. Note that they have replaced a reversing contactor. However, these reactors will do more than provide reverse operation.

With both forward and reverse reactors in the circuit, essentially the entire line voltage appears across these reactors. However, as the forward reactors become saturated by a d-c winding, an increasing amount of current is permitted to flow. The shape of the speed-torque curve will essentially be determined by the amount of resistance in the wound-rotor secondary. The diagram of Figure 11 shows how the torques can be made to vary from maximum positive through zero torque to maximum negative. The area in the loops represents the amount of torque and the arrows represent the direction of torque. This drive is commonly used for crane and hoist applications. It is also being used to control roof sections on an amphitheater in Pittsburgh,

as well as rod control in an atomic power reactor. This type of drive is very useful where careful positioning is required.

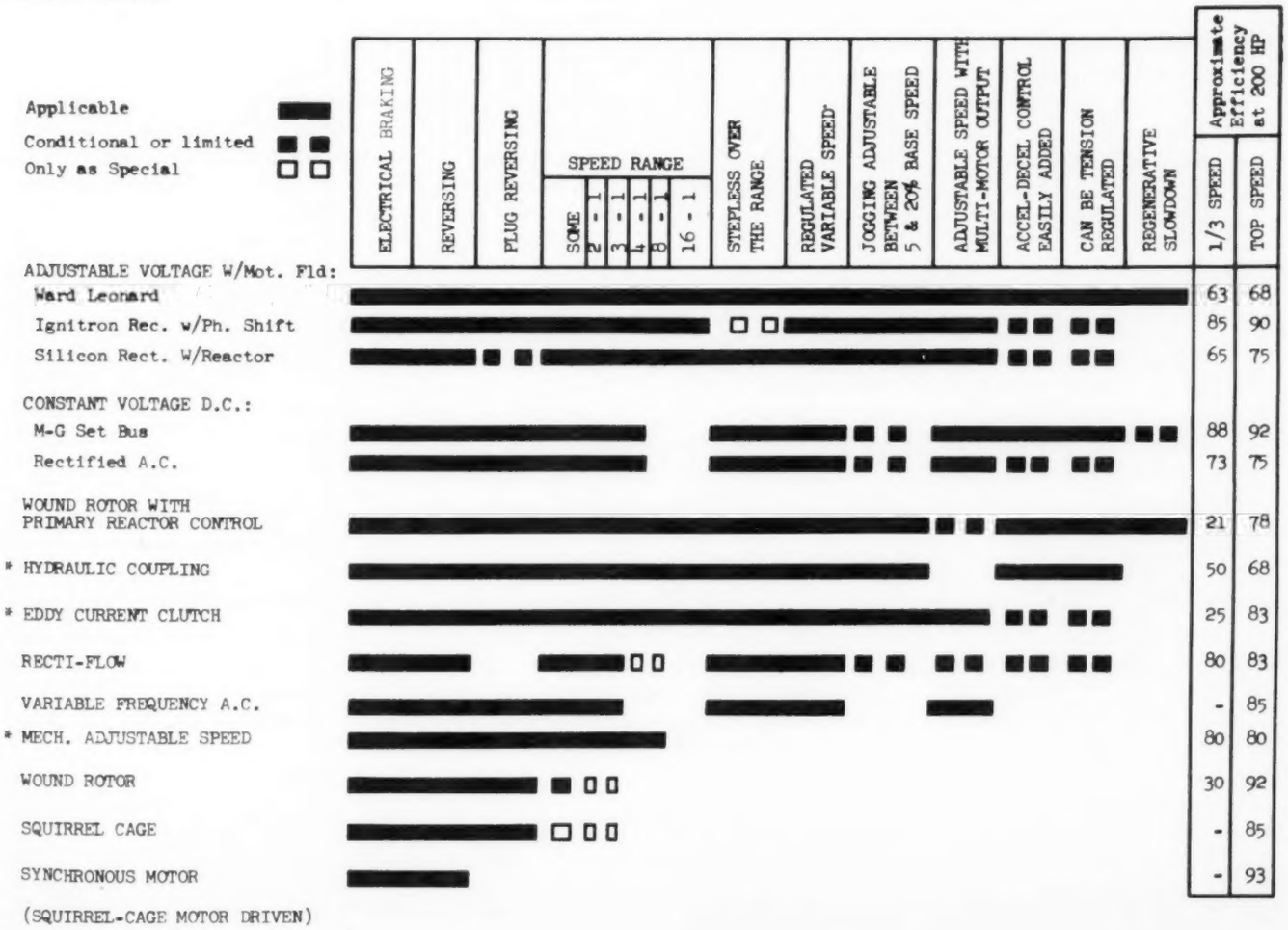
*Constant Voltage d-c*—Whenever consideration is given to using a constant voltage d-c motor with speed control by weakening motor field, the concept of reduced torque at the higher speeds should always be present. The set of equations with the speed-torque curve of Figure 12 shows the reason for this reduced torque. The emf is equal to the terminal voltage except for the IR drop. Also, for any voltage generated it will be a direct function of the rate of cutting flux. If these two equations are combined and the voltage and current are maintained constant, then the only thing that can give an increase in speed is a reduction in flux. Obviously, a reduction in flux means a reduction in torque.

*Adjustable voltage systems*—The Ward-Leonard system shown in Figure 13 could well be considered the "master" of steel mill drives. The maximum torque capabilities of the system at rated armature current are constant through the armature voltage range. Since most processing applications in the steel industry are constant torque in nature over the speed range, motor field control is frequently not used. However, some process systems take advantage of the additional speed range by handling lighter gage strip at the higher speeds. This results in an increase in production. Where winding and unwind reels are involved in a process system, the Ward-Leonard system with field control on the reels fits the application inherently. If speed is to be maintained constant for a given strip thickness, it will normally be desirable to hold the strip tension constant. Field control of the d-c motor for reel build-up while line speed is constant represents a true constant hp application for a constant hp drive. As seen from the point of view of the winding reel, the motor runs initially at a high speed with a short torque arm. At full coil, the motor field is strengthened, slowing the motor down and providing the increased torque which is required to pull the same tension from a larger torque arm. Machinery builders are frequently urged to avoid designing reels for a build-up of greater than four to one because of the instability of d-c motors at very weak field.

The reactor controlled adjustable voltage d-c drive may serve equally well on applications where regeneration is not required and where floor space and maintenance costs are important. D-c control windings in the reactors excited by magnetic amplifiers provide excellent voltage control. Rectified direct current is usually obtained with a 3-phase full wave bridge rectifier circuit.

With an ignitron rectifier type of supply there will often be a number of d-c motors supplied from the system as a constant voltage source. Armature voltage adjustment can be achieved through phase-shifting of the rectifiers, but major reductions in speed are usually accompanied by tap adjustments on the rectifier transformer in order to maintain high power factor. With high inertia on the motors and good regulators,

**Figure 14 — Applicability of various controls to types of electrical prime movers indicates the versatility available to the design engineer.**



this change through the taps can be made with very little disturbance. The reason is that the regulator offers quick recovery by functioning into the phase shift circuit. This type of group drive arrangement has become popular on modern rod mills such as was installed recently at a steel company in Cleveland.

*Drive versatility chart*—The drive versatility chart, Figure 14, is intended to give an indication of the degree of versatility of various drives. It shows that the Ward-Leonard system with motor field control is at present the optimum of versatility for the adjustable speed drives. It has the features of dynamic braking, plug reversing, 16 to 1 stepless speed range or better, and it may be speed regulated. A fairly infinite selection of jogging speeds can be had and it is exceptionally well adapted to multiple drive systems where the speeds must "track." Controlled acceleration and deceleration are easily available and such a drive can be regulated for tension. It is one of the few drives which can be stopped by regeneration. If maximum versatility is needed, then some loss in efficiency is well justified.

The ignitron rectifier with phase shift control has many of the same features as the Ward-Leonard system except that if a high power factor is to be expected, the speed cannot be stepless over the adjustable voltage range. Acceleration control is available and the tension can be regulated on a given drive as long as the load is absorbing power. Because the rectifiers will not permit regeneration back into the system, negative tension cannot be obtained nor can the drive decelerate faster than the load will drive it down. This of course, holds strictly true only for single motor drives from a given supply. The efficiency of an ignitron rectifier supply is higher than the Ward-Leonard system mainly because the motor-generator set has been eliminated.

With the reactor-controlled rectified d-c supply (or "static" power source), basically the same characteristics apply as with the ignitron rectifier except that plug reversing is not generally supplied. It has the added advantage of stepless speed control over the entire range. This type of drive has been used in sintering plants. For example, at a sintering plant in Aliquippa there are 27 adjustable voltage rectifiers driving conveyors, coolers and feeders.

For applications where constant voltage d-c is satisfactory, it is important to note the limitations for such a system. As was discussed before, speed range is covered only with a sacrifice in torque and in order to get maximum torque at the weak field speeds it is sometimes necessary to have a larger d-c machine than would ordinarily be required. The speed range by field is generally limited to four to one, but motors can be built with a higher speed range. Jogging may be obtained by including an armature-shunt circuit. This may be relatively easily done if dynamic braking has already been furnished since the armature-shunt point will require the simultaneous use of dynamic braking resistance and starting resistors. Speed reduction by regeneration may be obtained only to the base speed of the drive.

For the rectified constant voltage source, the same limitations apply as on the motor-generator set bus with the additional restrictions that regeneration is not usually available and that deceleration control and negative tension regulation are limited as described previously. Where many constant voltage drives are in use, an individual motor might have regenerative characteristics provided it is a relatively small part of the total load.

*Wound rotor*—The wound-rotor drive with primary reactor control has a very great degree of versatility, with one important limitation—multi-motor speed control is not usually feasible. The low-speed efficiency is approximately 21 per cent.

*Eddy current clutch*—The eddy current clutch has many desirable features in control ability including the speed co-ordination of several drives in a system. However, there are certain disadvantages of this drive compared to the Ward-Leonard system that should not be overlooked. Inasmuch as the losses within the clutch increase appreciably with slip, the drive does not lend itself to being tension regulated by motor current feedback. The chart indicates the clutch's low efficiency at one third speed which is due to these losses.

*Rectifier modified Krämer system*—On this drive there are a number of methods of braking that can be used. One is the application of d-c dynamic braking by the d-c component. D-c dynamic braking could also be applied to the primary of the wound-rotor drive with the secondary circuit closed. Reversing on the system is accomplished by simultaneously reversing the field on the d-c machine and two of the a-c leads to the wound-rotor drive. In the same manner, it is electrically possible to plug reverse this drive, but this is not normally done. The economical speed range available is generally three to one. Jogging is accomplished by opening the a-c contactors to the wound-rotor drive and supplying a low a-c voltage to the slip rectifiers, thus putting torque on the d-c motor. This jogging speed can be changed by taps on the smaller transformer. This drive is used not only in the machine tool industry, but is being applied to some process lines including recoiler drives on pull-through type slitters. Using the synchro-tie principle, it is possible to operate another drive in synchronism where the auxiliary drive represents a small portion of the total horsepower load. Since the rectifier modified system has many of the features of the single constant voltage d-c drive, it can be supplied where a d-c constant voltage supply is loaded to capacity. This can then provide some relief from the constant potential system.

*Variable frequency a-c*—The variable frequency a-c system is normally limited to a three to one speed range, but higher ranges can be provided with special motors. It is stepless over the range and can be speed regulated. Jogging is not permissible. This means that the drives must accelerate up to at least one third speed in order to get any stable drive motion at all. Another disadvantage to this system is that individual motors may pull out and stall, especially at low frequencies.

*Mechanical adjustable speed drive*—This drive will usually not have a speed range greater than eight to one. Consideration is now being given to provide means for regulating speed and load.

*Squirrel cage*—The squirrel cage motor in and of itself is not generally involved in the consideration of an adjustable speed drive except where two or three definite speed points are desired. In such a case it may be specifically wound and controlled from a two, three or four speed starter.

It is possible to use a NEMA D motor in the same manner as a reactor-controlled wound-rotor motor to get regulated variable speeds.

*Synchronous motor*—The synchronous motor has its merit in being a constant speed drive regardless of load and it is generally used for continuous operation especially for power factor correction. Large fans, compressors and motor-generator sets are typical of its applications.

## COST INDEX TABLE

In Table I all prices were on the basis of net price to user, and all drives were compared on the basis of nominal 1750-rpm top speed adjustable to one third of top speed.

Basis for comparison is the Ward-Leonard type adjustable voltage system, packaged type drive with motor-generator set and control in a single cabinet. The service factor for the drive is 100 per cent. No braking, reversing, jogging or special modifications were considered.

A constant voltage system from a motor-generator set source would not normally be supplied for a single constant voltage d-c load. Hence it is assumed the motor-generator set would be approximately ten times the capacity for the motor hp shown.

The hydraulic, eddy current and mechanical adjustable speed drives include one of the above mentioned couplings, a squirrel cage motor and starter for the motor.

The squirrel cage motor is a three-speed, constant torque with the necessary starter.

## SUMMARY

Some of the fundamental features of drive versatility have been considered using the bar graph of Figure 14. The graph, by itself, is not intended to provide a comprehensive concept of all types of drives and their versatility, but can serve as a very useful tool in suggesting the possible drives for a given application. Some of the basic drives might even be used in combination. For example, suppose a constant potential d-c drive exists and it is desired to increase the horsepower capacity without replacing the entire system. A Ward-Leonard power supply can be added which is then controlled for a buck-boost arrangement in series with the constant potential d-c supply. There are three main advantages to this type of arrangement. First, it converts a constant voltage system to a Ward-Leonard system. Second, twice the rated horsepower is obtained from the existing motors because they will be operated at double voltage. Third, the adjustable voltage generator and drive motor are rated at only half the rating normally required of an independent Ward-Leonard system.

**TABLE I**

**Adjustable Speed Drives Cost Index Comparison**

| Type drive | Per cent customer cost | | | |
|---|---|---|---|---|
| | 7½ hp | 25 hp | 50 hp | 100 hp |
| Adjustable voltage (Ward-Leonard) d-c | 100 | 100 | 100 | 100 |
| Adjustable voltage (rectifier-reactor) d-c | 118 | 114 | 100 | 100 |
| Constant voltage d-c (motor- generator set bus)* | 128 | 106 | 92 | 94 |
| Constant voltage d-c (silicone rectifier) | 150 | 107 | 88 | 85 |
| Wound rotor with primary reactor** | 130 | 80 | 57 | 61 |
| Hydraulic coupling | 60 | 34 | 31 | 29 |
| Eddy current coupling | 76 | 67 | 63 | 46 |
| Rectifier modified Krämer system | 90 | 78 | 71 | 62 |
| Mechanical adjustable speed | 40 | 40 | 49 | 57 |
| Wound rotor | 42 | 34 | 29 | 29 |
| Squirrel cage (3-speed) | 40 | 27 | 24 | 29 |

* Motor-generator set and control price taken as ten per cent of price for motor-generator set and control for ten times hp requirement.

** Price comparison not verified.

It should be noted that before a drive selection is made, or even before going to this chart for a comparison of drives, a very thorough and careful study should be made of the application. Many times electrical drives themselves are given the blame for certain troubles when in reality it is simply a misapplication of the drive.

In addition to some of the things discussed, other considerations as to the type of drive selected might fall under three main categories:

1. Cost items
2. Productive effects
3. Local conditions

The first cost of equipment is, of course, very important. Maintenance costs are also an important consideration and a close look at efficiency is always worthwhile.

Those factors affecting production are: the dependability of equipment, the advantages of having equipment interchangeable and the time in which the equipment can be made available for production.

The local conditions which should always be considered are the existing power supply, the available space for the equipment and the merits of supplying new mechanical equipment to go along with modern electrical systems. ▲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**ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.**

# European Experience with the Electrically Heated Soaking Pit

by H. C. BJERKE
Special Engineer
Rust Furnace Co.
Pittsburgh, Pa.

*. . . . electric soaking pits have proved competitive in heating alloy steels and can be competitive in a high tonnage mill if the ingot track time is relatively short . . . .*

EUROPEAN experience with the electrically heated soaking pit dates back to 1927 when the first full-scale production unit was designed and erected at the Christiania Spigerverk Iron and Steel Works in Oslo, Norway. Since that time the entire production of this mill has been passed through electric pits.

Systematic introduction of electric soaking pits to steel mills in other countries was not considered feasible, however, until several years after World War II.

At that time, it became evident that the inherent advantages of electric heating would, in the future, be economically justified in many parts of the world due to the favorable trend in cost and availability of electrical energy with respect to other forms of energy.

Since 1954, the electric soaking pit has found wide acceptance in European steel mills, which together cover the whole range of qualities, including carbon, stainless and alloy steels.

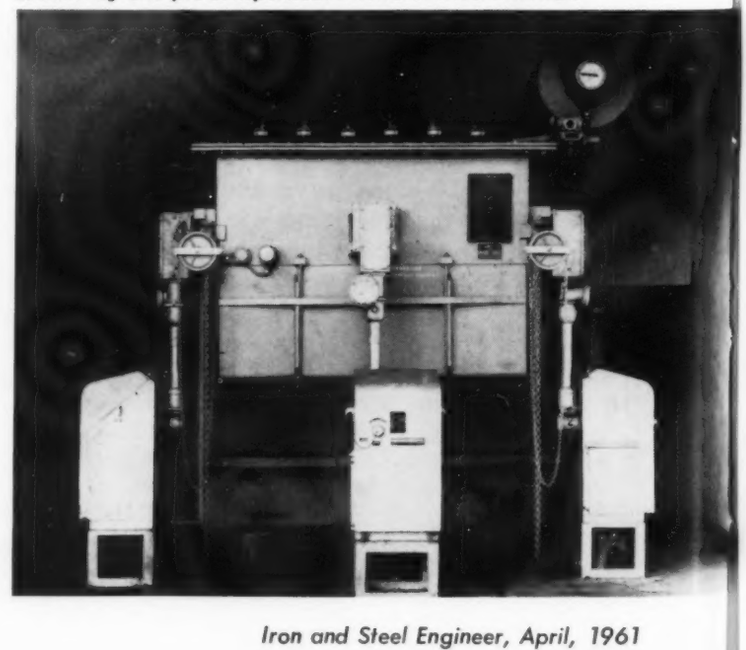
An electric soaking pit installation is very simple and consists of only two main blocks of equipment, namely, the pit proper and the electrical equipment. The pit itself consists of a rectangular steel casing heavily bound in rolled steel sections, and containing a refractory lining and insulation to form a closed unit. The internal brickwork divides the pit into a number of cells, each of which may hold one or more ingots depending upon ingot size. The cells are provided with individual covers which are handled with a special cover lifting machine.

The heating elements are coke-filled refractory troughs which run the entire length of the pit through arched openings in the walls which separate the cells.

Power is applied to the heating elements via electrodes which are led through the pit walls at each end.

Flexible connections and bus bars connect the electrodes to the secondary side of the furnace transformers (Figure 1) which are provided with means for varying the secondary voltage for the purpose of adjusting the power. This function is completely automatic and is governed by the temperature controller which calls

**Figure 1 — Power adjustment, accomplished by varying the secondary voltage, is an automatic operation controlled by the pit temperature control instruments.**



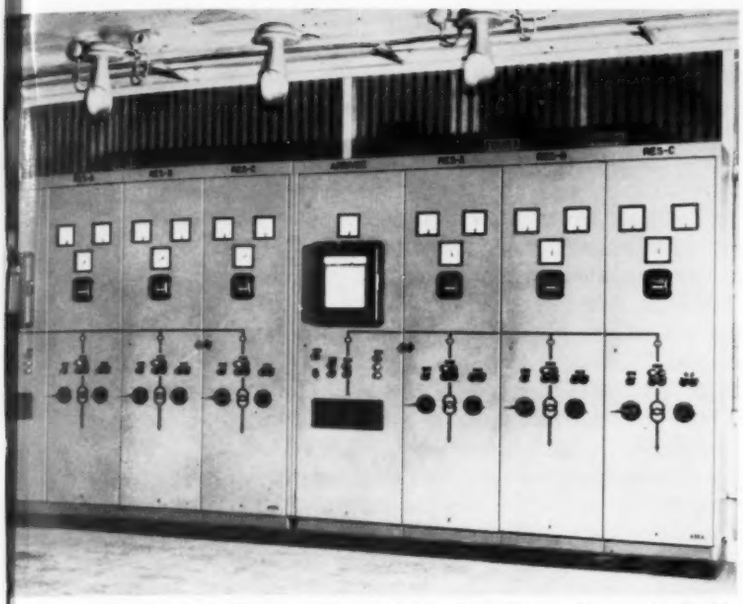


**Figure 2 — Each resistor of the 3-resistor pit can be individually operated from its own panel board.**

for preselected power levels according to pit temperature.

The control instruments and standard electrical circuit components are collected on a centrally located control panel such as shown in Figure 2. This particular panel is for a battery of two electric pits with three resistors each. It comprises a common section with temperature control instrument and fault indicating center, and a separate section for each resistor with meters for secondary volts and kw, transformer tap changer position indicator and kwhr meter as well as switches, push buttons and signal lights for circuit breaker control and auto or manual selection.

The electrical equipment may be placed anywhere within a reasonable distance from the pit, but the most convenient arrangement will, in most cases, be that where the transformers are placed in the adjacent bay, and the control panel is placed on top of the transformer cubicles.

## MAIN FEATURES

The electric soaking pit offers certain characteristic and desirable features which are not readily available with fuel-fired pits.

1. Controlled scaling.
2. Controlled atmosphere.
3. Gentle heating and temperature uniformity.
4. Low standing losses.
5. Simple installation, operation and maintenance.
6. Near unity power factor.

The relative importance of these features will change from case to case, but usually the possibility of controlling the atmosphere is placed at the top of the list.

The normal atmosphere, which prevails in an electric soaking pit as a result of the oxygen reacting with the resistor coke, is sufficiently reducing to prevent scale from forming on the ingots. In the majority of installations, this normal atmosphere is giving completely satisfactory results with an increased yield of one to three per cent over conventional pits, and improved surface without rolled-in scale.

However, on some mills a certain amount of scale is desirable in order to remove defects from the ingot surface.

Figure 3 shows the practical results obtained when introducing air into an electric pit for the purpose of removing scabs from the lower end of the ingots. The scale first forms near the bottom of the ingot and subsequently progresses upwards. It is particularly interesting to note how the scale jacket relatively quickly reaches a thickness of about $\frac{1}{8}$ in. and thereafter grows very slowly to greater thickness.

The scaling process is carried out at the end of the soaking period for a length of time as determined by the heater when the ingots were charged.

By the use of this method, it is possible to retain full control of the scale formation and thus combine the advantages of scale-free heating with those of surface conditioning by scaling to achieve optimum results. Large defects may not be removed even by a heavy scale jacket; however, it has been found that a light scale, less than $\frac{1}{16}$ in., in most cases will be as effective as the heavy scale normally found in fuel-fired pits.

The opposite problem is posed in those cases where it is desired to heat steel in a neutral or carburizing atmosphere. Figure 4 is a microphotograph, showing the carburized surface of a $3\frac{1}{4}$-in. sq billet rolled from a 19-in. sq ingot. Free cementite appears in this case to a depth of 0.018 in., but more or less may be obtained by varying the carbon potential of the atmosphere as well as the time.

For temperatures above 2000 F, there is presently no other type of furnace which readily lends itself to operation with such a wide range of atmosphere.

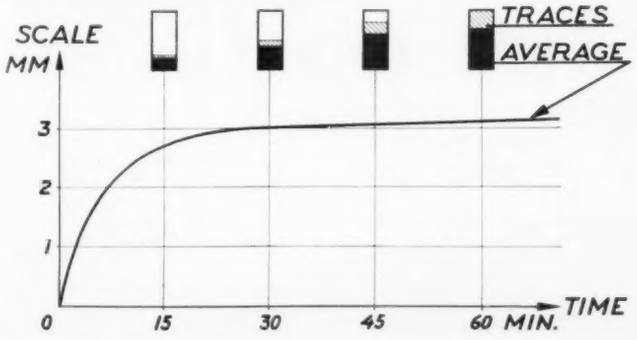
The practical significance of the other main features are best illustrated in connection with a description of various installations.

## FOUR TYPES

Electric pits are designed to suit the local conditions, but there are basically four types which have been found practical.

The schematic cross sections of Figure 5 shows pit brickwork, heating elements and ingots. There will usually be from three to six cells in each row, depending upon the size of the ingots and the space available.

**Figure 3 — Air must be introduced into the pit to permit scale to form on the ingot, giving close control of scaling by the operator. Chart is based on air addition at rate of 189.6 standard cfm of dry air.**



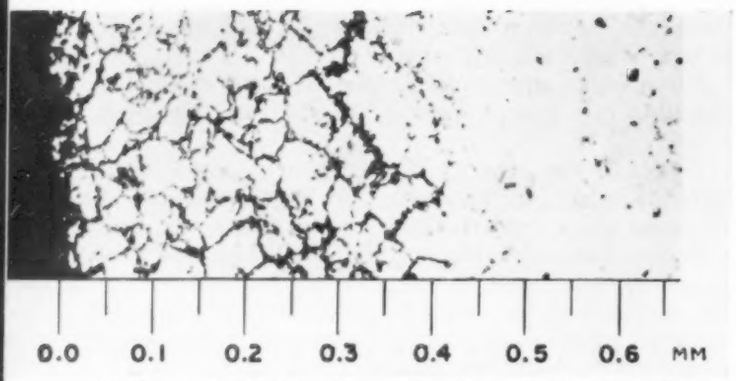



**Figure 4 — Pit atmosphere variation can be controlled to effect ingot carburization as evidenced by the microphotograph of a 3¼-in. billet showing free cementite to a depth of 0.018 in. Time in the pit was 2 hr-48 min and carbon content of the billet was 0.91 per cent.**

Each row of ingots may be heated by ½, 1, 1½ and 2 resistors, and in each case the choice of type is governed by ingot size and by the required heating capacity.

The single-resistor type is characterized by having a high holding capacity and a relatively small investment in electrical equipment, while the 2-resistor pit has a relatively small holding capacity and a large investment in electrical equipment.

The first type would be chosen if the ingots arrive with short track time and merely require soaking and very little further heat addition. The high-power unit is chosen for those applications where the ingots or slabs are charged cold, or with long track time.

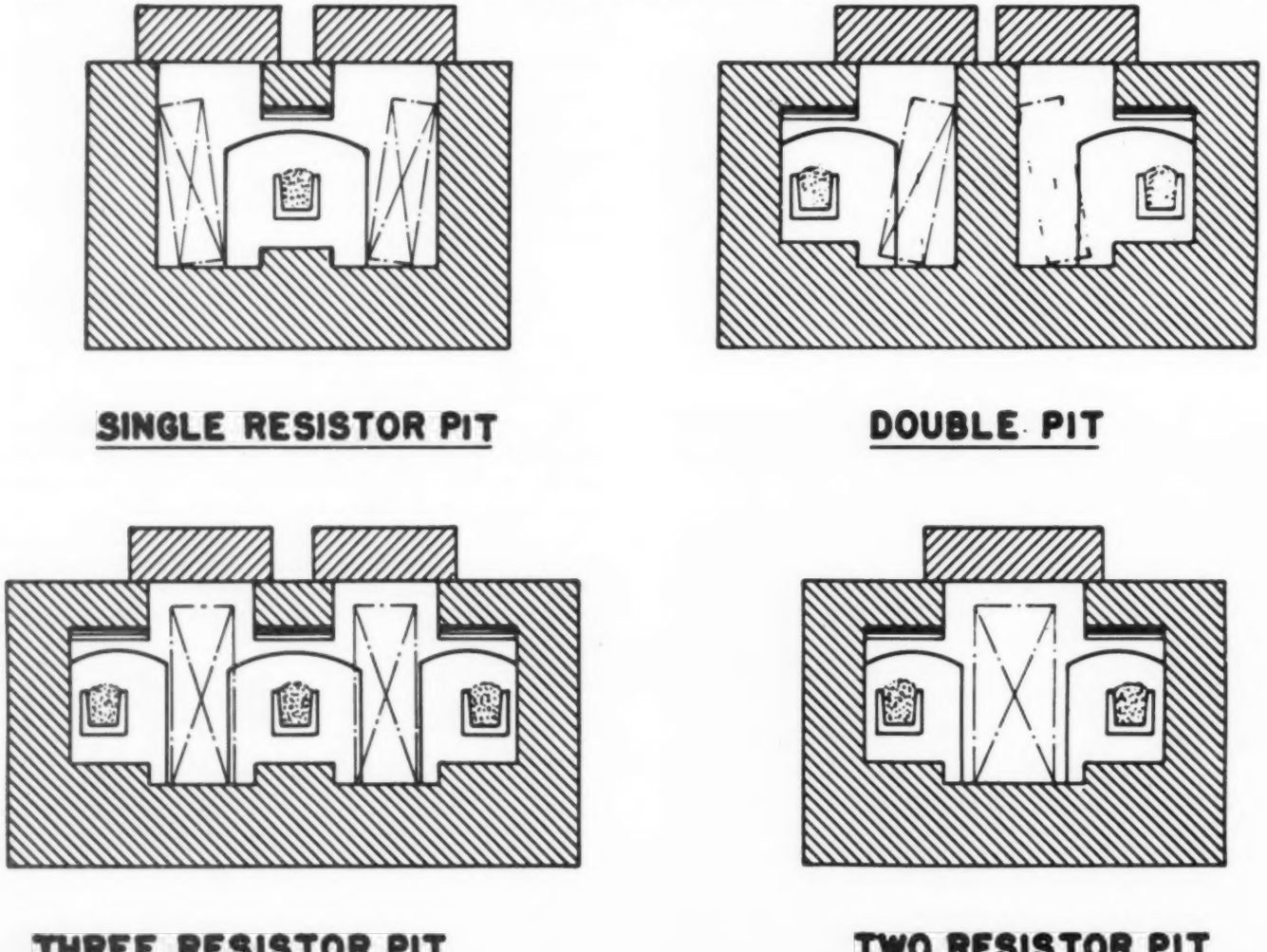
For intermediate conditions, one of the other two types may be more suitable.

There are at the present time nearly 40 units operating in various European countries, and 12 more units are undergoing design or erection.

*Single-resistor pit*—Figure 6 shows an electric soaking pit, operating at Appleby-Frodingham Steel Co., England. The pit has over-all dimensions of 43 x 19 ft with two rows of four cells each. The single resistor is here placed centrally in such a manner that the energy is radiated to both sides where eight 11-ton slab ingots are placed one in each cell. The resistor is connected to a 900-kva single-phase transformer. The standing losses are about 300 kw. The power available to heat steel is thus about 600 kw, but normally very little additional heat is required by the ingots. The ingots arrive at the soaking pits from the open hearth melting shop in batches of 88 tons which correspond to the contents of one ladle. Track time for the first heat is very short, and usually amounts to about 100 to 120 min reckoned from finish tapping furnace to finish charge.

The old practice was to charge these ingots, which

**Figure 5 — Four basic types of pits are in use, the type of pit being determined by ingot size and ingot capacity requirements.**



still had molten centers, to unfired Gjers pits since they would be too hot to charge directly to fuel-fired pits. A Gjers pit is seen behind the electric pit. Occasionally, it had been possible to roll an ingot directly from the Gjers pit; however, most often these ingots would have cold ends and corners and were normally transferred to the gas-fired pits where they remained about one hr for soaking.

The purpose of the electric pit was, in this case, to serve as a "heated" Gjers pit where the ingots could be soaked and kept ready for rolling. With about 2500 tons being passed through the electric pit per week, a considerable reduction in ingot handling and a corresponding increase in the heating capacity of the soaking pit plant as a whole have been experienced.

The slabs are normally passed straight on to the plate mill reheating furnaces without surface conditioning. It has been found that for the removal of minor surface defects, a slight amount of scale amounting to about 0.3 per cent is sufficient. Compared with the gas-fired pits, a metal saving of at least one per cent, and better surface finish without rolled-in scale, are gained with electric heating.

Ingots with larger defects may not be dressed by scaling in either type of pits, and these slabs are cooled down and flame scarfed before they are passed on to the plate mill.

The average energy consumption when accounting for all the energy required for heating up, idling and waiting is less than 22 kwhr per ton.

*Double pit*—The next general type to be considered is the double pit where there is one resistor per row of ingots, and a central wall dividing the unit in two independently controlled sections. This, by the way, is the arrangement which was first tried, and which has been used at Christiania Spigerverk in Oslo for the past 30 years.

The largest to date of this type are the four pits at Phoenix-Rheinrohr A.G., Duisburg, Germany, where they are processing heats of 80 to 90 tons of ten ingots from the new Thomas shop. Figure 7 shows two of these electric soaking pits placed next to modern 1-way fired soaking pits burning mixed coke-oven and blast furnace gas. The control panels for all pits are placed on an elevated platform from which also all cover lifting machines are operated.

It has been found that the electric pits are more effective than one had dared hope for. With 8.5-ton ingots having a track time of about 65 to 70 min reckoned from finish teem to finish charge, the production is higher than from the gas-fired pits occupying the same area. The main reason for the higher production is that the electric pit may be recharged cell by cell as soon as each one is emptied.

The tonnage passed through each unit is about 3000 tons per week, corresponding to about 4½-hr cycle charge-to-charge. The energy consumption under these conditions amounts to about 27 kwhr per ton as a weekly average including Sunday when the mill is not operating.

*The 3-resistor pit*—The next general type to be considered is the 3-resistor pit which may be regarded as a combination of the single-resistor and the double pit, inasmuch as the central wall of the double pit has been removed and a central resistor placed there instead.

**Figure 6 — This 8-cell, single resistor pit has been installed to reduce the handling formerly required when two pits were used in heating the ingots.**

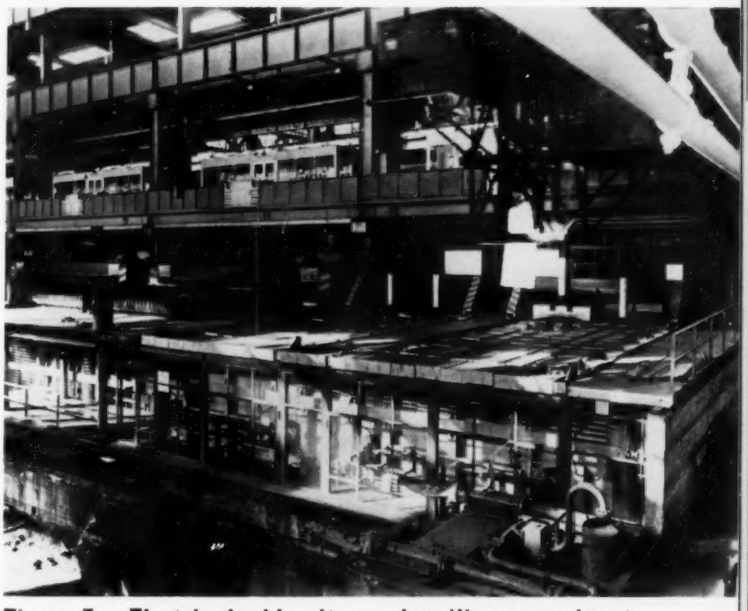
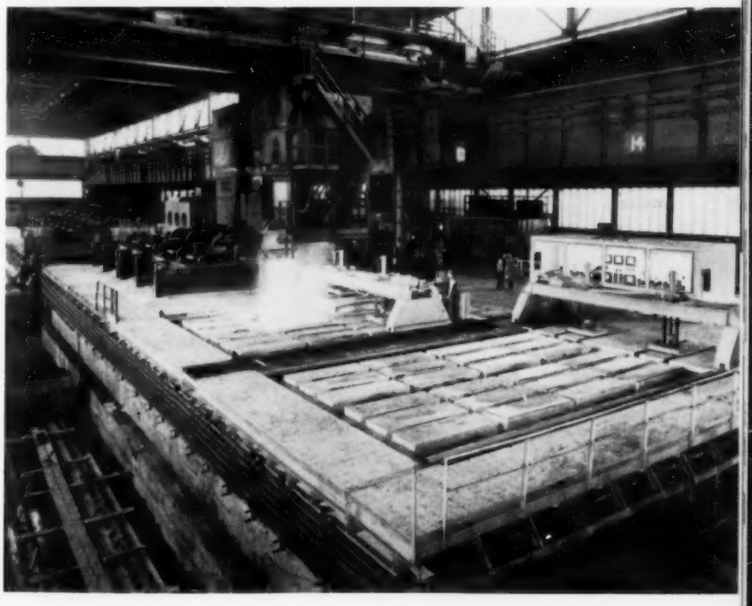


**Figure 7 — Electric double pits are handling more ingot tons than modern gas-fired pits occupying the same area.**

**Figure 8 — The 3-resistor pit is intended to make available sufficient energy to heat ingots with prolonged track time at a reasonable rate.**



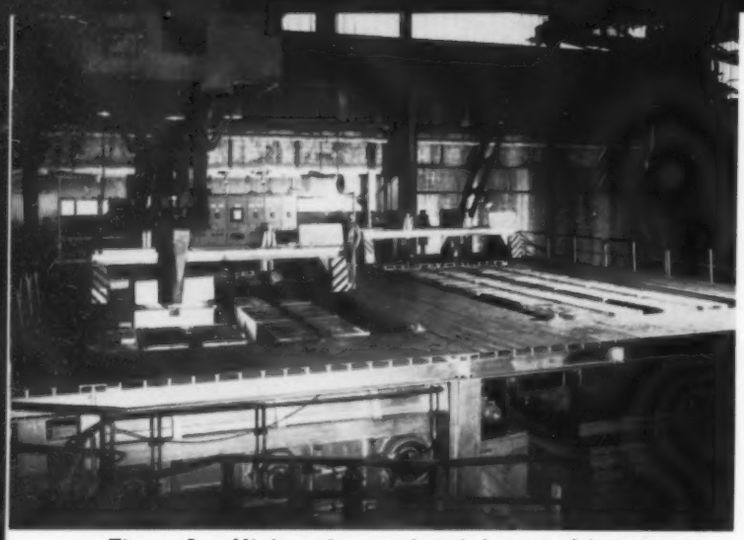


**Figure 9 — High carbon and stainless steel ingots are reheated and soaked evenly without the formation of scale or any danger of sectional overheating.**

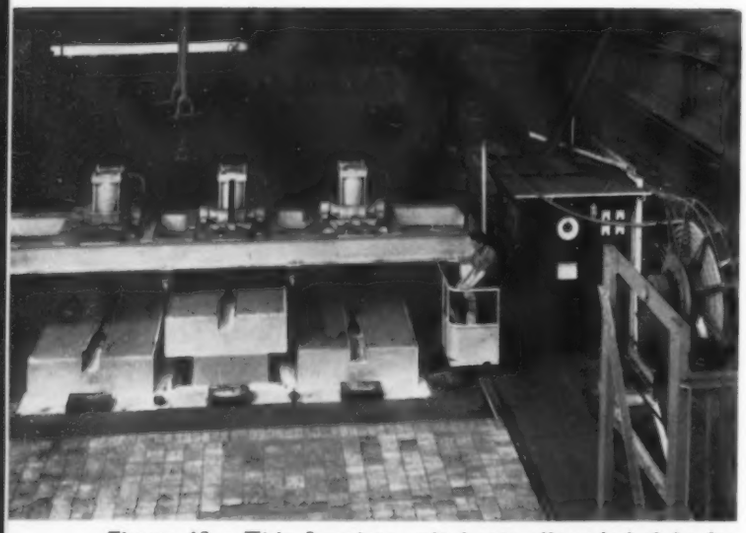


**Figure 10 — This 2-resistor pit heats alloy clad slabs for subsequent rolling into plates. Plate quality has been considerably improved.**

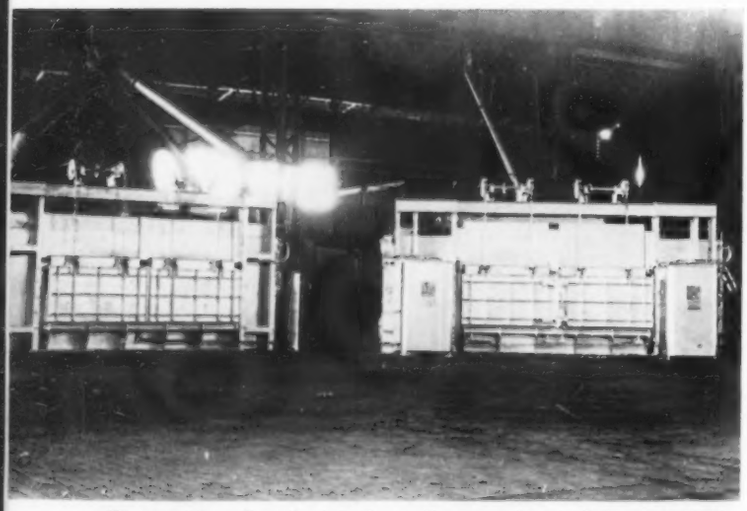


**Figure 11 — An electric forge furnace heats 9-in. sq billets with negligible scale formation.**

It will be appreciated that the central resistor will materially increase the heating capacity and improve the temperature uniformity, but the extra cost of the resistor and the electrical equipment must be considered.

Figure 8 shows two units operating at Consett Iron Co., Ltd., Durham, England. These pits were put into operation in the late summer of 1958. Each of these units has eight cells placed in two rows of four cells each. In each cell may be placed two 11-ton ingots or one 22-ton ingot making the holding capacity of each unit 175 tons.

The electric pits are intended to be used for tonnage heating of hot ingots arriving normally with short track time, but with the risk of bunched heats and longer track time being present, the 3-resistor type was chosen for ingots of this size.

The transformers and high tension equipment are placed on the ground level behind the pits, while the control panel is located on platform level.

Other large tonnage pits of this type are operated at Domnarfvet Steel Works, Sweden, and at South Durham Iron & Steel Co., Ltd., England.

Another extremely successful installation is operating at Ugine, France, where they are charging high-carbon, alloy and stainless steel ingots up to 4400 lb each.

Heating problems prompted installation of the first unit in 1957, and the advantages were such that a further two units were installed in the fall of 1959. Figure 9 shows these two units which provide gentle heating of quality steel ingots which are charged at an average temperature of about 1300 F. One of the main objects is to reheat and soak these ingots without scale formation and absolutely evenly to avoid overheating and other metallurgical difficulties.

The energy consumption in this case is higher per ton of ingots than for the high tonnage installations so far described. The advantages more than balance the energy cost; however, at Ugine all difficult qualities are presently processed through the electric pit.

*The 2-resistor pit*—As an example of this type, Figure 10 shows an electric soaking pit operating at Colvilles Ltd., Scotland. In this case, the single row of ingots is heated from both sides in order to obtain a high heating capacity.

The purpose for which this electric pit was installed was to heat heavy composite slabs for rolling into stainless clad plate, and for reheating of dressed slabs of special quality steel.

Each composite slab represents a considerable investment in material and labor by the time it is ready for rolling, and the relatively high cost of electric heating from cold is therefore more than balanced, as rejects caused by faulty heating are now nil.

The need for surface conditioning by grinding of the finished plates has practically disappeared due to the scale-free heating afforded by electric heating.

The theoretical amount of energy required to heat the steel amounts to approximately 225 kwhr per ton from cold to 2250 F, but the actual energy consumption charge-to-ready including losses will for a cold charge be in the region of 300 to 330 kwhr per ton depending on the weight of the charge, and on the time allowed for soaking. Normal heating and soaking cycle for 10-ton slabs amounts to about 20 hr when heating from cold.

A similar installation is presently being designed for Degerfors, Sweden.

## WHERE TO INSTALL

It will be appreciated that electric soaking pits are operated by both special steel and tonnage mills.

Important factors to be considered in connection with an economic analysis are cost of electric power, direct and incidental savings due to scale-free heating, quality of heating and possibility of operating with controlled atmosphere, space requirements, simplified maintenance and simplicity of operation.

The usual price of electric energy in Europe is about 0.6 to 1.4¢ per kwhr. A few steel mills generate their electric power by using their own gas, and it is interesting to note that these companies have calculated that the energy costs are in favor of electric pits if the energy consumption is less than 30 to 35 kwhr per ton.

While straight energy costs may be the most important single factor in tonnage steel mills, the scale savings are also significant and should be considered.

For the electric pit to be competitive in tonnage mills, however, it requires hot steel with relatively short track time, and the optimum balance between fuel-fired and electric pits must be determined in each case.

A very interesting application for the electric soaking pits is to operate these in step with oxygen steel plants, owing to the short track times ordinarily prevailing. The first mill to take advantage of the greater production capacity and lower capital and operating costs of the electric soaking pit is De Wendel & Cie S.A., France, who will install three units in connection with their new L-D plant.

When heating special steel or when faced with special operating conditions, one will find that the over-all cost may be in favor of electric pits even though the direct energy cost may be relatively high. With special steel the advantages of gentle heating, temperature uniformity over prolonged soaking periods or the benefits to be derived from operating with controlled atmosphere may be decisive.

## OTHER FURNACE TYPES

Having so far dealt with the basic heating principle as originally developed in connection with soaking pits, one cannot leave this subject without mentioning briefly that there are interesting fields of application in connection with forge furnaces and special furnaces. The potential advantages of electric heating and atmosphere control are considerable, but have previously been unattainable due to lack of suitable heating elements in this temperature range.

Figure 11 shows an electrically heated forge furnace which was built in 1957 at Societe Commentryenne des Aciers Fins, Vanadium Alloys, France, for the purpose of heating alloy steels.

The usual production cycle calls for preheating the 9-in. sq billets in the oil-fired furnace seen to the left. The preheated billets are at the end of the day transferred to the electric furnace at a temperature of about 1400 F. This charge of about 4.5 to 6.5 tons is heated during the evening, and soaked during the night for a period of six to seven hrs at full temperature before forging operations commence in the morning. During the night, small quantities of oil are introduced in order to assure completely scale-free heating.

During the day while forging, the process calls for several reheating operations. It has proved impossible to entirely avoid scale formation during the day, but the amount is insignificant in comparison with what is formed in the conventional forge furnaces, and is actually less than 0.01 in. Based on the operating experience gained with this first electric forge furnace, the same company recently commissioned a second electric furnace.

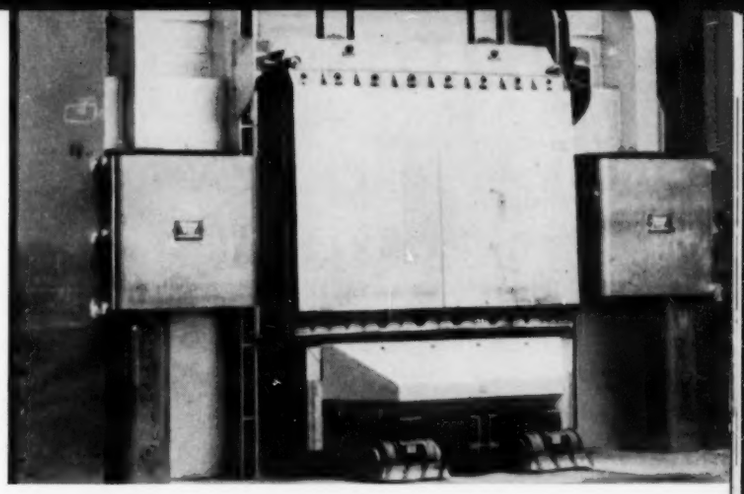


**Figure 12 — Large forgings are heated in this 55-ton capacity electric car bottom furnace.**

Figure 12 shows a large electric car type furnace which was commissioned in the late summer of 1958 at Gesellschaft Der Ludwig von Rollschen Eisenwerke A.G., Switzerland. The furnace is designed for a maximum charge of about 55 tons. This furnace represents the ultimate in flexibility inasmuch as it may be used for very critical preheating, as well as for scale-free finish heating for forging. Subsequent heat treatment at intermediate temperatures may also be carried out.

Another special application will be a continuous pusher furnace now being designed for an English tube mill.

## SUMMARY

It has been the object of this paper to describe the electrically heated soaking pit as it has been developed in Europe. It is believed that electric heating of high-temperature furnaces will be the natural development as nuclear generation of electric energy, which today is in its infancy, in a few years will be common all over the world. As shown in the past, one will probably find that the future cost of electric energy will become even lower with respect to other energy forms.

# Discussion

**PRESENTED BY**

**F. H. SPIESS, Combustion Engineer, Alan Wood Steel Co., Conshohocken, Pa.**

**H. C. BJERKE, Special Engineer, Rust Furnace Corp., Pittsburgh, Pa.**

**L. B. SHEETZ, Manager, Planning and Estimating, Allegheny Ludlum Steel Co., Pittsburgh, Pa.**

**F. W. FOSTER, Senior Industrial Power Engineer, West Penn Power Co., Greensburg, Pa.**

**F. H. Spiess:** Some work has been done in the U. S. in heating large sections by the electrical induction method, but power requirements are prohibitive except in locations ideal to sufficient low cost electric power.

The European companies who figure the breakeven

point of 30 to 35 kwhr are in line with our own fuel estimates. Figuring electric power costs of 1¼¢ per kwhr would be 37 to 44¢ per ton heated, which would be equivalent to five gal of oil at 7¢ a gal.

However, you mentioned a figure of 225 kwhr for heating cold steel, which is about $2.80 a ton, and completely out of line with fuel-fired cold steel heating. The heating of special steels, changes in pit design and resistor locations, with other savings in increased yield or pit repairs, could no doubt bring down the over-all heating costs.

We agree that the future cost of electric power will be greatly reduced when atomic power plants are someday used in the steel industry, and surplus fuels of blast furnace gas and coke gas will be utilized in a more valuable manner than for heating facilities.

The author mentioned four main types of pits which vary in design in the type of resistors used for heating or holding steel at rolling temperatures. The pits all seem to be divided into cells holding one or two ingots.

These small pits certainly have advantages, but in this country we tend to build larger pits and load them down with a number of ingots. How do you think this would work with the electrical soaking pit when the ingots would be behind one another and not in line with radiation from the resistors?

**H. C. Bjerke:** There is no doubt that if you want to heat ingots fast, it is no use bunching them together. With electric heating, where there is very little convection to sweep cold surfaces, you would have to place the ingots so that they can receive radiation from the brickwork, and from the resistor. One may get away with less radiation, however, when the ingots are charged hot.

You were touching upon the question of cost of operation, and you are certainly quite right. There will be no point to install electric pits to heat cold ingots of low-carbon steel of commercial qualities. Gas or oil firing would be much cheaper in this country.

We believe that there are two main fields of application. One case is where very hot ingots arrive regularly and we are thinking immediately of the oxygen processes where you have good scheduling. The ingots should arrive at the pits with all their heat in them, and they need a place where they can stand while soaking. The electric pit would do that very nicely and will have a greater production capacity than gas-fired pits since without having to wait for the whole pit to be emptied, you can start recharging as soon as you start drawing to the mill.

The other main field of application is with the producers of special steel. These mills are faced with a variety of problems which may be costly to correct by conventional methods.

The electric pit will give them a chance to reduce their finishing costs, and will give great control. You have greater margin of safety; you will not risk burning or ruining your ingots by overheating them; and you will also have the advantage of uniformity of temperature throughout the pit even when long soaking times are required.

The electric soaking pits will not be the right choice for all mills, and a careful analysis of problems and costs will have to be conducted in each case.

**L. B. Sheetz:** It may come as a shock to some fuel engineers to find out that you have to deliberately blow air into a pit in order to make the ingots scale, but that seems to be the case, and it is being done.

There is one thing that might be considered an engineering point, and that is this matter of compartments or cells within these pits. Obviously, there are many advantages to them, you can back-charge just as soon as you draw one compartment, but it is a basic design difference, inasmuch as the mass of refractory walls within these pits acts as a thermal flywheel and this in turn allows you to operate with a lower maximum energy input to the pits. Therefore you do not need as big transformers or contactors. However, the pit in turn does not seem to recover quite as fast as our fuel-fired pits.

These cells could become quite a scheduling problem, especially in steel mills where the melting furnaces can make either seven ingots or 17 ingots, and if you have an 8-hole pit, what do you do with the ingot that is left over, or the blank space that is left?

**H. C. Bjerke:** It is quite true that it is not always possible to fill the pit to capacity, and in that case the cells are left free. If you carry that out and regularly had fewer ingots than spaces, and always left the same cell less loaded than the others, you would be able to draw the heat out of the heavily charged cells, in case there are cold ingots being charged. You could overheat the cells that had a heavy load of hot ingots, but by normal practice you would, from charge to charge, leave another space free.

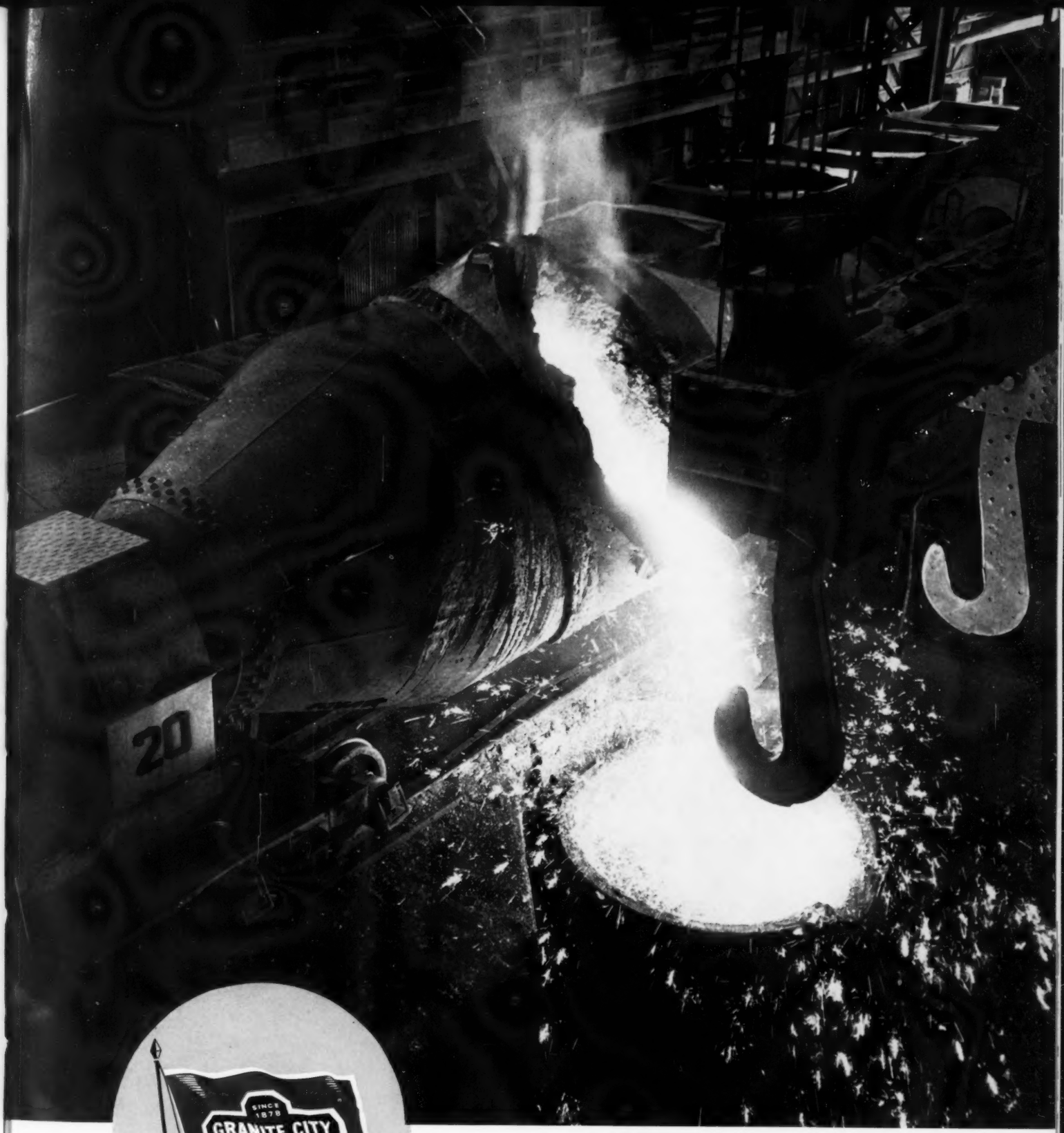
If you have more ingots than you have space, you have to put the extra ingot in another pit. By proper planning such problems are usually avoided.

The flywheel effect of the brickwork is taken into consideration when designing the pits for specific installations. If there are heats coming in requiring different soaking temperatures, therefore requiring the heating of the brickwork, as much brickwork as possible would be eliminated, for instance a 3-resistor pit would be used.

When you speak of heat recovery, you are thinking of getting back up to set point temperature. With the lower power input that we have in electric pits, you will find that the temperature will rise at a lower rate than what you read on your pit temperature recorders in a fuel-fired pit where the thermocouples are extremely sensitive to the furnace gas temperature and less affected by the ingots.

In the electric pits, the recorders read much closer to the actual ingot temperature while heating, and while the temperature comes up more slowly than in the fuel-fired pit, you will find that the ingots are ready for rolling shortly after set point is reached.

**F. W. Foster:** Electric soaking pits require relatively large amounts of power, but the loads are steady and on nearly all power schedules the cost of electricity on a per kwhr basis would be lower for soaking pits than the average costs most plants now pay. When making an economic study, it is important that these incremental costs be established and used rather than average plant costs. Load control, such as now used on arc furnaces, might also be applied in some cases. It is believed that an evaluation of costs would show that electric soaking pits could be profitably used in U. S. plants today. ▲




SINCE 1878
GRANITE CITY STEEL

# GRANITE CITY STEEL COMPANY

**NICHOLAS P. VEEDER**
Chairman of the Board and President

# GRANITE CITY STEEL COMPANY

*by T. J. Ess*

ALTHOUGH recognizing 1878 as the year of its origin, Granite City Steel Co. can trace roots back to a small tin shop established in 1857. To insure a supply of sheet iron for the original St. Louis Stamping Co., incorporated in 1866, The Granite Iron Rolling Mills were built in St. Louis in 1878. This plant was designed for the production of wrought iron, with subsequent reduction to sheet form. As tin mills, galvanizing equipment and other finishing facilities were added, it became necessary to expand.

In 1892, a plant site was purchased at what is now Granite City, Ill., across the Mississippi river and about nine miles north of downtown St. Louis. The Granite City Steel Works was built on that site, and the first heat tapped in 1895. The steel works consisted of open hearth furnaces, blooming mill, sheet bar mill, jobbing mill and plate mill. In 1899, the steel works was consolidated with the St. Louis Stamping Works, the Granite Iron Rolling Mills and other major producers of household enameled ware in the National Enameling and Stamping Co. (NESCO). Open hearth capacity was increased the next year and tin mills installed, and the plant was expanded over the years that followed.

In 1923, a new sheet mill was installed there. In 1927, the steelmaking activities of NESCO were separated from the manufacturing division and incorporated as the Granite City Steel Co.

In 1937 a 90-in. semicontinuous hot strip mill was built, followed by cold reduction mills and other finishing equipment. Since World War II the company has expanded and rounded out its facilities to become the 16th largest steel producer in the U. S. In 1951 the company purchased coke ovens and two blast furnaces from an operating division of Koppers Co., Inc. Additional ovens have been built and the two blast furnaces have been rebuilt and enlarged. New open hearth facilities were built and subsequently expanded. The company now has some of the largest furnaces in the country. The postwar program also included new soaking pits, a new slabbing mill, a complete rebuild of the hot strip mill and cold mill and new finishing facilities.

## RAW MATERIALS

Although almost all of the raw materials requirements are at present purchased on the outside, the company is planning ownership or control of the sources for much of its iron ore during the next few years. It is engaged with American Zinc, Lead and Smelting Co. in joint exploration of iron ore deposits in southeast Missouri, less than 100 miles from the plant.

At present, iron ore comes principally from Minnesota and from several deposits in Missouri, arriving at the plant by rail. Cars are unloaded by a car dumper into a 120-ton transfer car which moves the ore to a trough running along the storage yard. Ore is then put into the yard by a 12-ton bridge. The yard is 1600 x 275 ft and will accommodate 500,000 gross tons of ore.

Ore is reclaimed by the bridge, loaded into a 60-ton transfer car and dumped into the stock bins beneath the furnace high-line.

Some high-grade ore is also imported from Peru.

**JAMES L. HAMILTON, JR.**
**Executive Vice President and General Manager of Sales**

**TABLE I**
**Iron Ore Analyses**

| | Fe | $SiO_2$ | $Al_2O_3$ | Bases | P | Mn |
|---|---|---|---|---|---|---|
| Spring Valley fines (Minnesota) | 47.99 | 5.49 | 0.40 | 0.31 | 0.224 | 1.29 |
| Groveland concentrate (Minnesota) | 56.80 | 7.90 | 0.38 | 0.205 | 0.026 | 0.34 |
| Chatfield fines (Minnesota) | 49.65 | 4.97 | 0.86 | 0.20 | 0.199 | 0.74 |
| Marcona fines (Peru) | 57.21 | 5.45 | 1.16 | 1.51 | 0.057 | 0.15 |
| Iron Mountain fines (Missouri) | 54.91 | 9.20 | 2.87 | 3.08 | 0.020 | 0.36 |
| Iron Mountain coarse (Missouri) | 53.25 | 12.25 | 3.90 | 3.40 | 0.022 | 0.35 |
| Miscellaneous Missouri ores | 48.62 | 12.06 | 1.01 | 0.29 | 0.038 | 0.09 |

Table I gives average analyses of the ores used. Approximately 180,000 tons of ore are used for a full month's operation.

High volatile coal comes from Illinois mines, and is washed at the mines. Low volatile coal comes from West Virginia. All coal arrives at the plant in hopper cars which are dumped by the car dumper into a transfer car which, in turn, unloads the coal into a track hopper or into a section of the ore yard pit, where it is handled by the ore bridge in the same manner as stock ore. The coal dumped into the track hopper is conveyed to the crusher building by means of a pan conveyor.

Table II shows average coal analyses. Approximately 105,000 tons of coking coal per month are required for full operation.

Limestone is obtained by rail from quarries at Valmeyer, Ill., in two grades. Some fine stone goes directly to the sintering plant where it is used in the mix to make a partially self-fluxing sinter. Coarse stone, sized to 2 x 5 in., is unloaded and handled by the car dumper transfer cars and bridge in the same way ore is handled. Limestone analyses are about as follows:

| | *Per cent* |
|---|---|
| $SiO_2$ | 0.19– 0.49 |
| $Al_2O_3$ | 0.78– 1.00 |
| Bases | 53.39–53.85 |
| Phosphorus | 0.05– 0.069 |

For full operation, approximately 18,000 tons of stone are used per month.

## COKE PLANT

Three batteries (one still under construction) of by-product coke ovens provide facilities for coking 3400 tons of coal per day. The batteries contain 27, 49 and 61 ovens, respectively. The first two are of underjet design, the third is of gun flue type. All ovens are 15½ and 18½ in. wide, 40 ft-5½ in. long and 13 ft high. Filled to one foot from the top, they offer a volume of 688 cu ft and hold 17 tons of coal each.

Coal is conveyed to one of two 250-ton per hr crushers where it is broken down to minus ⅜ in. The coal is then moved by belt conveyors to three 200-ton mixing bins. The various coals are drawn from these bins in the desired proportions and mixed by an apron mixer. A normal mixture might contain 25 per cent of West Virginia low volatile coal, 20 per cent of the Illinois No. 5 and 55 per cent of the Illinois No. 6. The mixture is then conveyed to one of two 300-ton per hr pulverizers, where it is reduced so that 82 per cent will pass through a ⅛-in. screen.

The pulverized coal mixture is conveyed to a 1550-ton stock bunker at the oven batteries. A 17.5-ton larry car moves coal from these bins to each individual oven.

The ovens are fired with coke-oven gas, using about 47 per cent of the total gas make. Gross coking time is normally about 16½ hr, giving a total of 199 ovens per day.

Two pusher machines push coke into a quenching car which is moved by electric locomotive to a concrete quenching tower. The quenched coke is then spread evenly over the coke wharf and, when sufficiently cooled, carried by belt conveyor to the screening station. Here it is separated into furnace, nut and breeze sizes. Coke yields average 65.4 per cent furnace coke, 1.8 per cent nut coke and 5 per cent pea coke and breeze. Furnace coke (plus 1 in.) is moved to the blast furnaces by transfer car.

**Coking facilities are being expanded to a total of 137 by-product ovens, capable of making 70,000 tons of coke per month.**

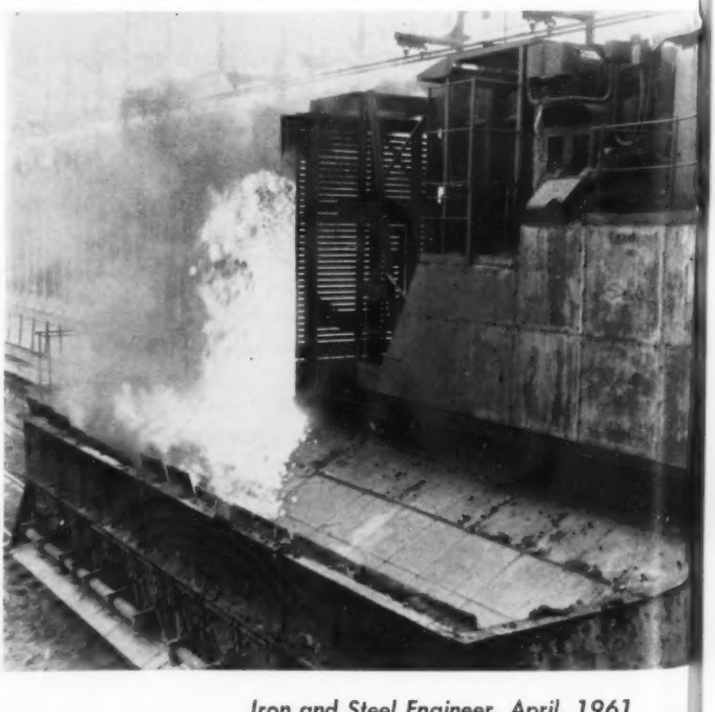


**TABLE II**
**Coal Analyses**

| | High Volatile | | Low Volatile, West Virginia |
|---|---|---|---|
| | Illinois No. 5 | Illinois No. 6 | |
| Volatile | 36.7 | 38.0 | 16.8 |
| Ash | 7.2 | 7.0 | 6.2 |
| Sulphur | 1.30 | 0.77 | 0.61 |
| Moisture | 7.2 | 8.5 | 5.0 |

**LYLE F. GULLEY**
Vice President
in Charge of Operations

**HAROLD A. MUTTACH**
Works Manager

By-product recovery follows the conventional pattern, with six indirect primary coolers, raw tar recovery system, ammonium sulphate facilities, naphthalene recovery and two light oil scrubbers. Light oils are further treated in a continuous $CS_2$ column and a continuous pure column in the benzol plant to recover benzol, toluol and xylol. By-product yields per ton of coal coked are approximately 11,000 cu ft of gas, 6.3 gal of tar, 3.0 gal of light oils and 25 lb of ammonium sulphate.

Surplus coke oven gas flows through a 50,000-cu ft gas holder and is then boosted to 15 to 20 psi for transmission to soaking pits and boilers.

## BLAST FURNACES

Iron making facilities at Granite City consist of two modern blast furnaces which provide a total annual capacity of 1,134,000 net tons. Proportions of these furnaces are given in Table III.

"B" furnace is a new one, just recently completed. The steel shell and most of the top equipment were assembled on an elevated platform 87½ ft from the old furnace which was in production. The old furnace was then torn down and the new shell moved over a temporary trestle and lowered into place.

The furnaces are cooled by water-jacketed cast iron hearth staves in the hearth area. "A" furnace has copper cooling plates in the tuyère jacket and in the bosh up to the mantle. "B" furnace has water-jacketed tuyère and bosh jackets, both of steel. Both furnaces have seven rows of copper cooling plates above the mantle.

Each furnace is charged by a conventional double skip dumping into a rotating distributor top. Bells are operated through levers and cables by pneumatic cylinders actuated from the cold blast. Semi-automatic charging control is provided for each furnace. The usual charging sequence is ore, stone, coke/ore, coke, coke.

Coke is charged by volume on furnace A and by weight on furnace B. Ore and stone are weighed for both furnaces by scale cars.

Blast for the furnaces is provided by four steam turboblowers, two rated at 40,000 cfm each, one at 50,000 cfm and one at 125,000 cfm. The first three are equipped with barometric condensers. The large unit has a surface condenser.

The blast is heated in two-pass, side-combustion stoves listed in Table III. Checkerwork is constructed of 9-in. hexagon brick giving 2-in. flues. The stoves are operated two hr on blast before changing. Blast temperature is controlled by an automatic mixer valve for each furnace. Moisture content of the blast is usually

**Gas from the coke ovens is put through conventional coal chemical recovery facilities to produce tar, ammonium sulphate, benzol, toluol and xylol.**

**TABLE III**
**Blast Furnace Data**

| Furnace | A | B |
|---|---|---|
| Diameter of hearth, ft-in. | 25-0 | 28-0 |
| Diameter of bosh, ft-in. | 28-3 | 31-3 |
| Diameter of stockline, ft-in. | 20-0 | 22-0 |
| Height, bottom to top ring, ft-in. | 106-0 | 106-0 |
| Height, iron notch to stockline, ft-in. | 81-6 | 81-4 |
| Height of crucible, ft-in. | 10-6 | 12-0 |
| Height of bosh, ft-in. | 10-6 | 11-0 |
| Height of straight section, ft-in. | 9-0 | 9-1 |
| Height of inwall section, ft-in. | 53-6 | 52-9 |
| Height, stockline section to top ring, ft-in. | 22-6 | 22-9 |
| Height, bottom to iron notch, ft-in. | 2-0 | 2-0 |
| Height, iron notch to cinder notch, ft-in. | 4-2 | 4-2 |
| Height, cinder notch to tuyeres, ft-in. | 3-4 | 3-4 |
| Working volume, tuyeres to stockline, cu ft | 38, 011 | 46,930 |
| Bosh angle, deg-min-sec | 81-12-10 | 81-35-40 |
| Inwall slope, in. per ft | 0.925 | 1.052 |
| No. of tuyeres | 18 | 20 |
| Tuyeres diameter, in. | 5 and 6 | 5 and 6 |
| No. of columns | 9 | 8 |
| Lining thickness, crucible, in. | 3-9 | 2-3(c) |
| Lining thickness, bosh, in. | 2-3 | 1-3 and 1-6(c) |
| Lining thickness, stack, in. | 4-6 | 3-0 |
| Lining thickness, throat, in. | 3-9 | 2-8⅜ |
| Big bell diameter, ft-in. | 15-0 | 15-0 |
| Big bell, angle, deg | 53 | 53 |
| Small bell diameter, ft-in. | 6-6 | 7-0 |
| No. of gas offtakes | 4 | 4 |
| Diameter of offtakes, ft-in. | 5-9 | 5-9 |
| Date last blown in | 7/21/56 | 1961 |
| No. of stoves | 3 | 3 |
| Stove diameter, ft-in. | 25-2 | 22-0 |
| Stove height, ft-in. | 104-0 | 132-0 |
| Checker openings, in. | 2 | 2 |
| Heating surface per stove, sq ft | 193,012 | 223,221 |
| Blast volume, cfm, average | 75,000 | 90,000 |
| Blast volume, cfm, maximum | 80,000 | 100,000 |
| Blast temperature, F, average | 1500 | 1400 |
| Blast temperature, F, maximum | 1600 | 1500 |
| Blast pressure at tuyeres, psi | 18 | 22 |
| Top pressure | 1½ | 4 |
| Top temperature, F | 250 | 300 |
| Daily iron production, average, net tons | 1450 | 1750 |
| Daily iron production, maximum, net tons | 1800 | 2000 |

(c) denotes carbon lining.

controlled at 12 to 15 grains per cu ft by the addition of steam to the blast. Stoves consume about 30 per cent of the blast furnace gas produced. Gas and air for heating the stoves are proportioned by pressure burners under automatic control. Stove stack temperatures average about 650 F.

Gas leaves each furnace top through four off-takes which combine into two uptakes and finally into a single downcomer. Gas from A furnace passes through a dust-catcher, a wet tower washer and electrostatic precipitators. B furnace is served by a dust-catcher, a venturi scrubber and precipitators. Surplus blast furnace gas is used to underfire boilers.

Effluent from the wet washers is pumped to a pit where the sludge settles out.

The blast furnaces use approximately 3500 lb of iron ore and sinter, 375 lb of limestone and 1500 lb of coke per net ton of iron produced. About 60 per cent of the ore burden is sinter or pellets. Only basic iron is produced for use in the open hearth. The iron averages about one per cent silicon, 0.03 sulphur, 0.20 phosphorus and 0.9 manganese.

Each furnace is cast every five hr into 200-ton mixer-type ladle cars, which are then normally moved to the open hearth shop.

A double-strand pig machine is available for casting iron that is not wanted at the open hearth.

The furnaces make about 1000 lb of slag per ton of iron produced. About 25 per cent of the slag is expanded by pouring it through a stream of water. The remainder is put over a slag dump for processing by an outside company. Slag analyses run about as follows:

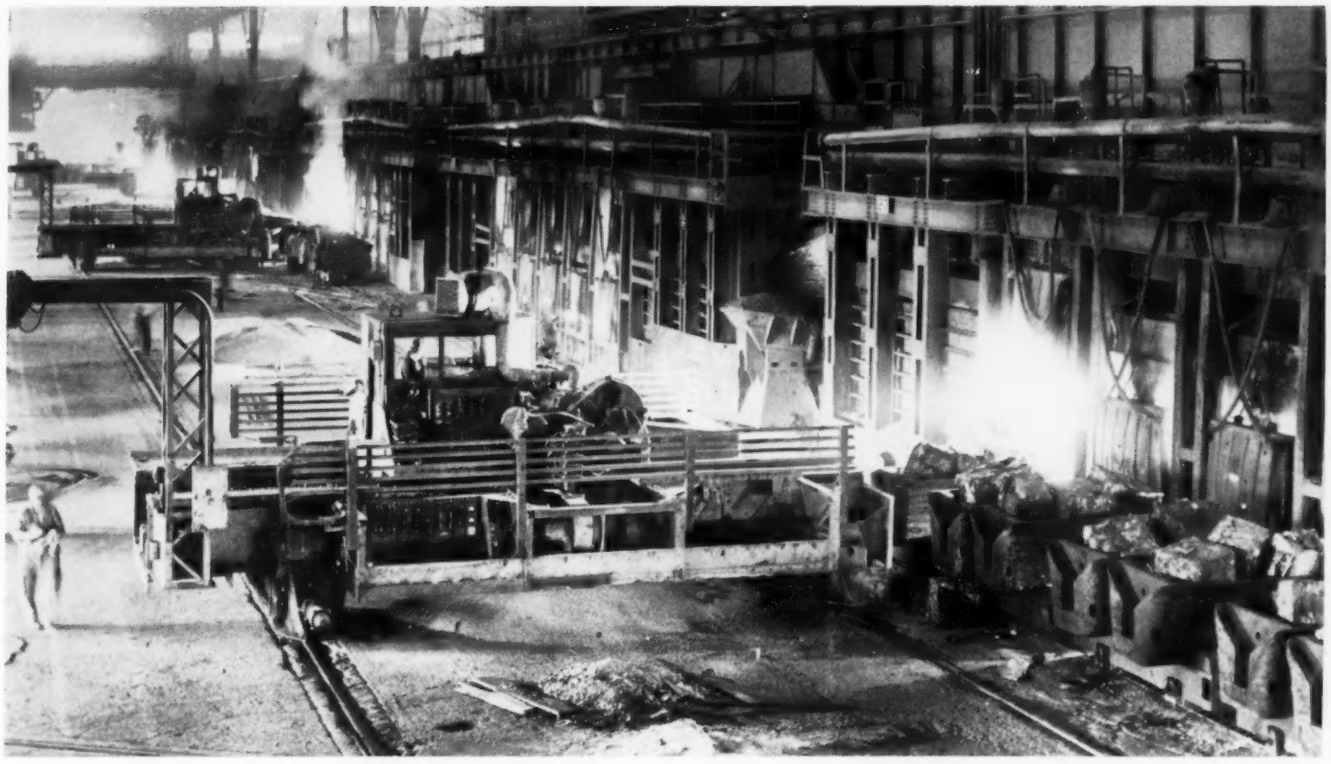
| | *Per cent* |
|---|---|
| $SiO_2$ | 37.0 |
| $Al_2O_3$ | 12.0 |
| CaO | 44.0 |
| MgO | 4.0 |
| S | 1.5 |
| Fe | 0.4 |
| Mn | 0.3 |

Flue dust runs about 25 lb per ton of iron produced. This, together with the fine ores and fine limestone, is processed in an 8 x 128-ft sinter machine rated at 2500 tons per day. This unit has 16 wind boxes and a suction fan rated at 280,000 cfm, 30-in. pressure at 300 F. The traveling grate discharges sinter on to a 5300-cu ft rotary sinter cooler equipped with three 50,000-cfm, 7-in. pressure fans.

## OPEN HEARTH

Granite City now produces steel in seven open hearth furnaces which have been enlarged over the years to give capacities of 250 to 500 tons. Table IV gives principal proportions of the furnaces. One 300-ton furnace is to be rebuilt to 600-ton capacity, which

**A recently completed blast furnace with a 28-ft hearth (foreground) brings iron capacity of the plant to 94,500 tons per month.**



**The seven open hearth furnaces are fired with fuel oil and natural gas. Oxygen is used through end burners for flame enrichment and through roof lances for decarburization.**

will raise the plant's annual ingot capacity to a projected 1,740,000 tons.

All furnace bottoms are built up with 2¼ in. of insulating concrete, 13½ to 18 in. of basic brick and 9 to 13½ in. of rammed mix.

Each furnace is equipped with a forced draft fan of 20,000 to 50,000-cfm capacity. All furnaces also have instruments to record and control oil flow, gas flow and fuel-air ratio. Automatic reversing equipment, based on checker flue temperatures or time, is provided. Immersion bath pyrometers are also used.

The furnaces are fired with bunker C fuel oil and natural gas through water-cooled artillery burners. Normal proportions are 30 per cent oil, 70 per cent gas. Fuel input runs about 100,000,000 Btu per hr. Fuel consumption averages 3,700,000 Btu per ton.

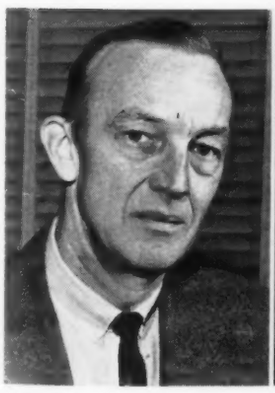
Oil is received in tank cars and trucks, and is stored in two 500,000-gal tanks. Oil temperature is automatically controlled at about 180 F by individual heaters at each furnace.

The shop produces carbon steels, principally in rimmed type. Analyses fall within the following limits:

| | *Per cent* |
|---|---|
| Carbon | 0.03–0.30 |
| Manganese | 0.20–1.05 |
| Phosphorus | Up to 0.15 |
| Sulphur | Up to 0.05 |
| Silicon | Up to 1.75 |
| Copper | Up to 0.40 |

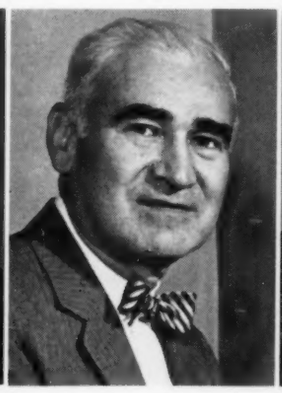
Furnace charges, which vary in weight for the various furnaces, normally consist of 42.5 per cent hot metal and the remainder of No. 2 bundles, No. 2 scrap, railroad and home scrap. Charged weights total about 12 per cent above the desired ingot weight. Consump-

**EDWARD D. BADGETT**
Chief Engineer



**FRANK J. BURGERT**
Divisional Superintendent
Hot Metals

**CLARENCE R. MITCHELL**
Divisional Superintendent
Rolling



**RUSSELL C. SOLOMON**
Divisional Superintendent
Finishing

**ARTHUR W. SCHOENEBECK**
Divisional Superintendent
Maintenance

**TABLE IV**
**Open Hearth Furnace Data**

| Furnace No. | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|
| Capacity, net tons per heat | 500 | 250 | 250 | 300 | 400 | 300 | 300 |
| Over-all length, ft-in. | 79-0 | 79-0 | 79-0 | 79-0 | 89-3 | 89-3 | 89-3 |
| Over-all, width, ft-in. | 26-5 | 23-11 | 23-11 | 23-11 | 24-5 | 24-5 | 24-5 |
| Hearth length @ sill plate, ft-in. | 58-8 | 46-0 | 46-0 | 58-8 | 61-6 | 56-0 | 56-0 |
| Hearth width @ sill plate, ft-in. | 20-6 | 16-9 | 16-9 | 16-9 | 16-9 | 16-9 | 16-9 |
| No. of doors | 7 | 5 | 5 | 7 | 7 | 5 | 5 |
| Sloping backwall | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Type of roof | Basic sprung | Silica sprung | Silica sprung | Silica sprung | Basic sprung | Basic sprung | Basic flat |
| Thickness of roof, in. | 15 & 12 | 15 & 18 | 15 & 18 | 15 & 18 | 12 | 15 & 12 | 12 |
| Span of roof, ft-in. | 24-1 7/8 | 21-8 1/4 | 21-8 1/4 | 21-8 1/4 | 22-0 7/16 | 22-0 7/16 | 21-5 |
| Spring of roof, ft-in. | 4-6 1/4 | 4-6 1/16 | 4-6 1/16 | 4-6 1/16 | 4-2 1/2 | 4-2 1/2 | None |
| Roof length between knuckles, ft-in. | 59-1 1/4 | 59-1 1/4 | 59-1 1/4 | 59-1 1/4 | 64-2 3/4 | 64-2 3/4 | 58-8 1/2 |
| Height, foreplate to skew, front, ft-in. | 5-11 1/2 | 5-11 1/2 | 5-11 1/2 | 5-1 1/2 | 5-11 1/2 | 5-11 1/2 | No skew back |
| Height, foreplate to skew back, ft-in. | 4-11 1/2 | 4-11 1/2 | 4-11 1/2 | 4-1 1/2 | 4-7 1/8 | 4-7 1/8 | No skew back |
| No. of downtakes, each end | 1 | 2 | 2 | 1 | 1 | 2 | 2 |
| Length of downtake, ft-in. | 18-0 | 7-3 | 7-3 | 18-0 | 15-3 | 9-4 1/2 | 9-4 1/2 |
| Width of downtake, ft-in. | 3-6 | 6-10 | 6-10 | 3-6 | 5-8 | 6-7 1/2 | 6-7 1/2 |
| Slag pocket length, ft-in. | 19-1 1/2 | 19-1 1/2 | 19-1 1/2 | 19-1 1/2 | 21-4 | 21-4 | 21-4 |
| Slag pocket width, ft-in. | 13-10 1/2 | 13-10 1/2 | 13-10 1/2 | 13-10 1/2 | 19-5 1/4 | 19-5 1/4 | 19-5 1/4 |
| Regenerators | | | | | | | |
| No. on each end | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Length, ft-in. | 30-0 | 30-0 | 30-0 | 30-0 | 32-3 | 32-3 | 32-3 |
| Width, ft-in. | 18-0 | 18-0 | 18-0 | 18-0 | 22-6 | 22-6 | 22-6 |
| Height, ft-in. | 22-11 | 22-11 | 22-11 | 22-11 | 22-11 | 22-11 | 22-11 |
| Depth of checkerwork, ft-in. | 13-6 | 13-6 | 13-6 | 13-6 | 15-7 1/2 | 15-7 1/2 | 15-7 1/2 |
| Checkerwork volume, each end, cu. ft. | 7250 | 7250 | 7250 | 7250 | 10,800 | 10,800 | 10,800 |
| Flue size | 7 1/2 | 7 1/2 | 7 1/2 | 7 1/2 | 7 1/2 | 7 1/2 | 7 1/2 |
| Areas, sq ft: | | | | | | | |
| Across center of furnace above bath | 190.1 | 182.7 | 182.7 | 182.7 | 165 | 165 | 170 |
| At furnace knuckle | 157.6 | 157.6 | 157.6 | 157.6 | 155.5 | 155.5 | 140 |
| Downtake | 65 | 99 | 99 | 65 | 86.3 | 123.6 | 123.6 |
| Regenerator bridgewall | 105 | 105 | 105 | 105 | 129 | 129 | 129 |
| Flues between regenerators and stacks | 34.13 | 34.13 | 34.13 | 34.13 | 52.2 | 52.2 | 52.2 |

tion of fluxes and miscellaneous materials average as follows:

| | *Lb per ton* |
|---|---|
| Ore and mill scale | 165 |
| Limestone | 133 |
| Burnt lime | 28 |
| Ferromanganese | 11 |
| Fluorspar | 3 |
| Graphite | 1 |
| Silico manganese | 0.13 |
| Aluminum | 0.4 |
| Ferrosilicon | 0.33 |
| Ferrophosphorus | 0.23 |
| Copper | 0.14 |

Hot metal comes from the blast furnaces in 200-ton mixer-type ladle cars and is poured into 50-ton ladles which are carried by overhead crane and emptied into the open hearths.

Oxygen is used during the heat for flame enrichment and for decarburization. For flame enrichment, oxygen is introduced through the end burners at a rate of 25,000 cu ft per hr. Roof lances provide the oxygen for decarburization at flows of 30,000 to 45,000 cu ft per hr for each lance.

Oxygen comes from an on-site plant consisting of three units of 5, 7 and 70 tons per day capacity, respectively. A new 175-ton per day oxygen plant is being built by an outside company, from which 125 tons per day of additional oxygen will be purchased.

Slag amounts to about 10 per cent of the total charge. Slag is flushed through the center front door to the ground, bulldozed into pits and then loaded into dump cars. Tapping slag flows into slag pots on the pouring floor. Open hearth slag is processed by an outside company for the recovery of metallics.

Overall, heats from the entire shop average about 327 net tons. Time of heats varies for the various sizes of furnaces. The smaller furnaces run about 12 hr-20 min, tap-to-tap. The largest averages about 17 hr. Over-all production averages 24 tons per furnace-hour. This rate will improve as more oxygen becomes available. Heats over 300 tons are tapped into two ladles,

**TABLE V**
**Open Hearth Buildings and Cranes**

| Building | Length, ft | Width, ft | Cranes | | |
|---|---|---|---|---|---|
| | | | No. | Capacity, tons | Span, ft |
| Stockyard | 650 | 110 | 4 | 10 | 65 |
| Leanto | 730 | 40 | .. | ... | .. |
| Charging bay | 1050 | 72 | 2 | 75/25 | 65 |
| | | | 3 | 7.5 | (Floor chargers) |
| Pouring bay | 1125 | 75 | 2 | 325/40/15 | 67 |
| | | | 2 | 350/60/15 | 67 |
| Mold yard | 250 | 79 | 1 | 50/15 | 75 |
| Stripper building | 880 | 79 | 1 | 150 | 75 |
| | | | 1 | 75 | 75 |

**Hot metal comes from the blast furnace in 200-ton mixer-type ladles and is poured into 50-ton ladles for charging into the open hearths.**

using a bifurcated runner. Steel ladles are of 200, 250 and 300-ton capacity.

Typical deoxidizing practice for rimmed steel calls for up to ½ lb of aluminum per ton of steel in the ladle and 0.5 to 1.5 oz per ton in the mold.

Ingots are usually cast in bottle-top molds 30 x 44 x 95 in., 30 x 55 x 95 in., 30 x 69 x 96 in. or 30 x 80 x 96 in. Open top molds 30 x 55 x 95 in. and 30 x 65 x 96 in. are also available. Before teeming, molds are sprayed with a dry mixture of dextrose and graphite.

After teeming, the mold train is moved by locomotive to the stripper building nearby, where the ingots are stripped and then taken to the soaking pits.

### SLABBING MILL

Ingots are roughed down into slabs on a new slabbing mill installed in 1953. Ingots are heated in 24 one-way fired recuperative soaking pits, arranged in eight blocks of three pits each. Each pit is 20 ft-8 in. long x 8 ft-6 in. wide x 12 ft-8 in. deep (11 ft-2 in. above coke breeze bottom). They are fired with coke-oven gas or natural gas through burners near the top of the end wall.

The pits are provided with refractory and metallic recuperators in series which preheat air for combustion to about 950 F. The air is supplied by 5300-cfm fans. Automatic controls regulate temperature, fuel-air ratio and furnace pressure.

Ingots charged into the pits are usually at temperatures of 1600 to 1800 F, although some 20 per cent may be charged cold. Heating time may range 5 to 20 hr, depending on the charging temperature. Fuel consumption averages 670,000 Btu per ton.

Ingots are handled into and out of the pits by two 25-ton telescopic stiff-leg pit cranes of 80-ft span. A self-propelled ingot buggy carries ingots at speeds up to 457 fpm to the receiving table of the mill.

The ingot is placed on the receiving table and proceeds over the mill approach table, ingot turn table and front mill table to the mill.

**Heats over 300 tons are tapped into two ladles, using a bifurcated runner.**

The mill is a 45 x 115-in., two-high, high-lift reversing unit. Housing posts present a cross-sectional area of 863 sq in. each. The cast steel rolls, of 45-in. maximum diameter, are 19 ft-11¾ in. over-all length and have a 115-in. body. They carry grooves of 7½ and 13½ in., and a bullhead 87 in. long. The roll necks run in oil-film bearings.

The rolls are adjusted by screws 17⅞ in. in diameter, 2¼-in. pitch, driven by two 200-hp, 230/460-volt d-c motors under adjustable voltage control. Roll lift speed may range up to 35.46 fpm and a maximum roll lift of 76 in. between bullheads is available. The top roll and spindle are balanced by mechanical counterweight.

On each side of the mill is a movable sideguard, operated through racks and pinions by two 150-hp d-c motors. The entry sideguard carries manipulator

**Ingots for the slabbing mill are heated in 24 one-way recuperative soaking pits fired with coke-oven gas or natural gas.**

**TABLE VI**
**Details of Slabbing Mill Tables**

| Table | No. of rollers | ℄ spacing, in. | Roller diameter, in. | Motor, hp | Table speed, fpm |
|---|---|---|---|---|---|
| Receiving | 6 | 29 | 18 | 75 | 212 |
| Mill approach | 12 | 29 | 18 | 150 | 405 |
| Turn table | 8 | 21½ | 17 to 18 | (2) 75 | 180/460 |
| Front mill | 14 | 29 | 20 | (4) 75 | 465/930 |
| Front feed rollers | 2 | 27 | 19½/21 | (2) 44 | 485/970* |
| Back feed rollers | 2 | 27 | 19½/21 | (2) 44 | 522/1044* |
| Back mill | 14 | 29 | 20 | (4) 75 | 465/930 |
| Edger approach | 11 | 29 | 18 | 150 | 203/508 |
| Edger runout | 12 | 29 | 18 | 100 | 228/564 |
| Edger runout | 12 | 29 | 18 | 100 | 228/564 |
| Edger runout | 12 | 29 | 18 | 100 | 298 |
| Shear approach | 9 | 29 | 18 | 150 | 297 |
| Pull back | 9 | 18 | 16 | (2) 35 | 308 |
| Shear delivery | 9 | 24 | 16 | 75 | 306 |
| Scale | 12 | 24 | 16 | 75 | 306 |
| Slab loading | 19 | 24 | 16 | 75 | 306 |
| Slab loading | 14 | 24 | 16 | 75 | 306 |
| Slab loading | | | | | |

* Vary with roller diameters.

fingers actuated by a 150-hp d-c motor. All manipulator drives are controlled by adjustable voltage.

On each side of the mill are two feed rollers individually driven by a 22/44-hp, d-c motor. Table VI gives data on the tables serving the mill.

The mill is driven by two 5000-hp, 700-volt, 0/40/80-rpm d-c motors in twin-drive arrangement. Rolls are connected to their motors by universal spindles of 23-in. minimum diameter.

D-c power for the drive comes from a five-unit motor generator set having four 2000-kw, 700-volt d-c generators, a 91,500-lb laminated steel plate flywheel 192 in. in diameter and 10 in. thick and a 7000-hp, 6900-volt, 514-rpm wound rotor motor. The drive develops a rated torque of 1,312,500 ft-lb and a maximum torque of 3,610,000 ft-lb.

**Automatic controls, regulating pit temperature, gas-air ratio and furnace pressure are grouped on panel boards located in control houses.**

The mill uses 14.75 kwhr per net ton of product.

Mill drive motors, with their motor-generator set, auxiliary sets, control equipment and switchgear, are located in the adjacent motor room. Rotating machinery is cooled by downdraft, with the room kept under pressure by a recirculating system. The air is cooled by surface type heat exchangers.

Auxiliaries of the 45-in. mill, including front and back mill tables, feed rollers, screwdowns, manipulators and shear, operate under adjustable voltage control, the drives receiving power from two 11-unit motor-generator sets, each totaling 1350 kw and driven by a 1750-hp, 6900-volt synchronous motor.

Three circulating oil systems are installed:

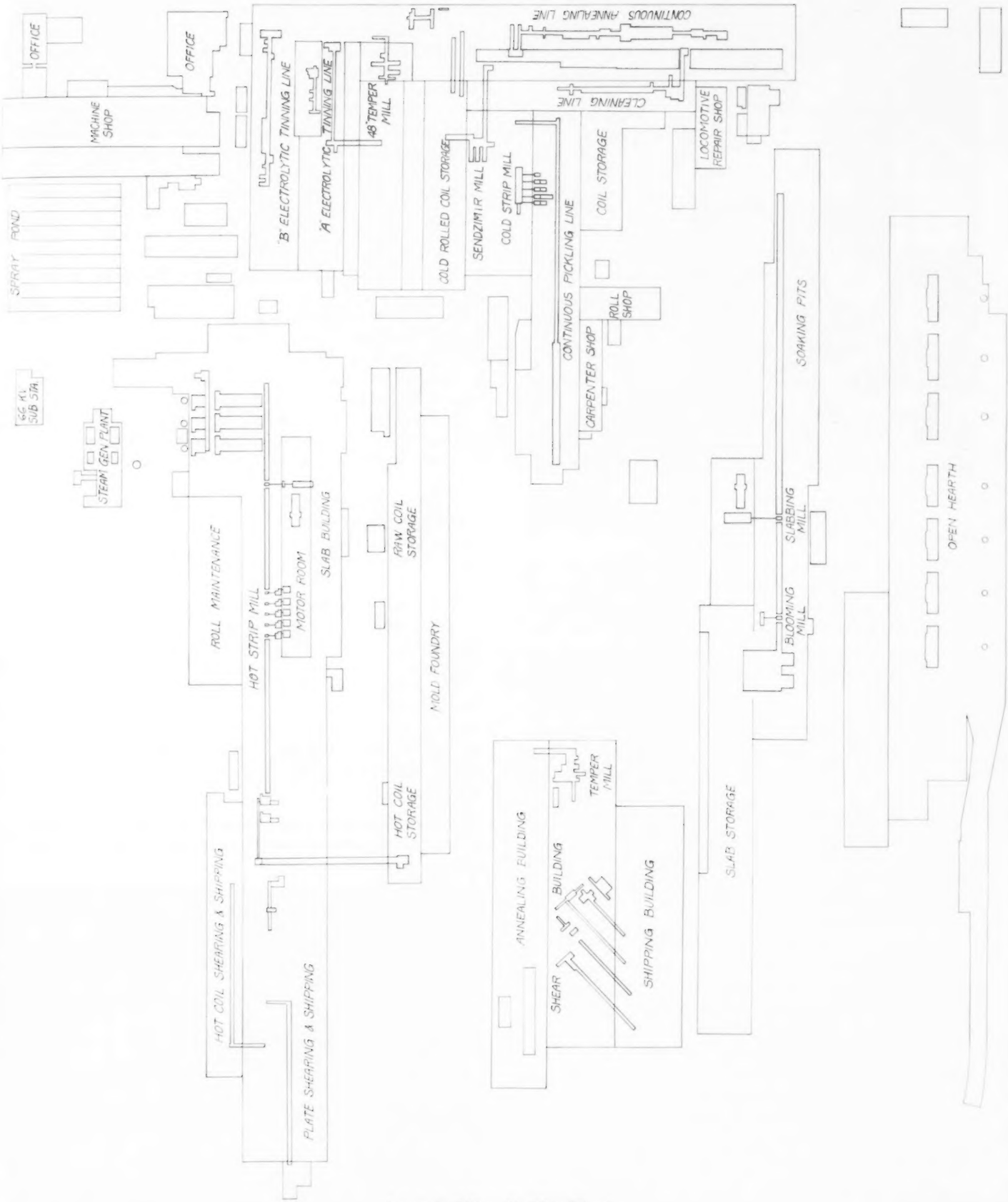
1. 8000-gal storage, 175-gpm circulation, serving mill tables with leaded gear oil of 1800/1875 SSU viscosity.
2. 3000-gal storage, 32-gpm circulation, serving mill roll neck bearings with straight mineral oil of 2410 SSU viscosity.
3. 4000-gal storage, 175-gpm circulation, serving screwdowns, manipulators, and front and back mill tables with leaded gear oil of 2400/2500 SSU viscosity.

More than 900 points are lubricated with a leaded calcium grease by 16 automatic grease systems.

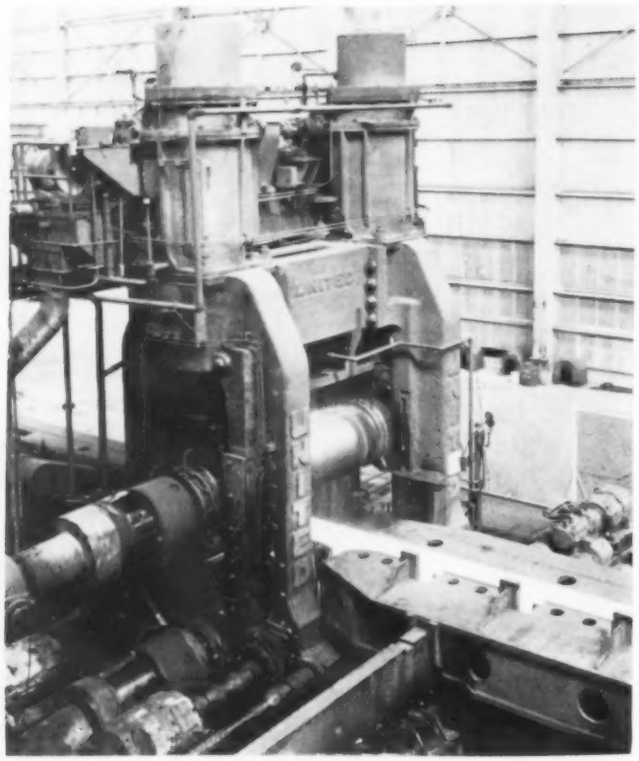
The slabbing mill receives ingots 96 in. long and approximately 31 in. thick in widths of 36, 44, 55, 69 and 80 in., and weights ranging 21,000 to 47,900 lb. It produces only slabs, usually 18 ft long, 24 to 76 in. wide and 4½ to 8 in. thick.

The mill rolls at an average rate of 318 tons per hr, but has rolled as much as 460 tons in an hour and 2911 tons in an 8-hr turn. Its monthly record is 119,001 tons, operating two turns per day. Maximum rolling speed is 944 fpm.

Mill scale falls through the tables into a flume beneath and is flushed to a settling basin. Scale is removed from the basin into hopper cars by a clam shell on an overhead crane.




**Layout of Granite City Plant**



**The 45-in. x 115-in. slabbing mill turns out slabs at an average rate of 318 tons per hr. It is driven by two 5000-hp motors in twin-drive arrangement.**

About 188 ft beyond the mill is a down-and-up cut shear which develops 3,000,000 lb pressure, cutting material up to 600 sq in. cross section. It has a stroke of 19 in. and a knife 90 in. long, and is driven by two 500-hp, 375/750-volt d-c motors under adjustable voltage control. A shear gage permits measurement of slabs from 5 to 20 ft long.

Crop ends from the shear slide down into a skip bucket which is periodically hoisted up through the side of the building and dumped on the ground. Crops are subsequently loaded into charging cars by magnet crane.

From the shear the slabs proceed on to the two loading tables, from where they are pushed off by double pushers on to two slab pilers. Piles of slabs are pushed from the pilers on to two transfer cars which move them into the adjacent slab storage area.

## HOT STRIP MILL

Slabs coming to the hot strip mill range 24 to 77 in. in width, 4 to 10 in. in thickness, 160 to 216 in. in length and 6600 to 21,800 lb in weight. The average slab weight is about 14,000 lb.

Slabs come from the slabbing mill on special narrow-gage cars and are unloaded and either put into a storage yard at the strip mill or loaded directly on a hydraulically-operated magazine elevator depiler. They are then pushed, one at a time, on to the furnace charging table, 146 ft long, running across the back ends of the furnaces.

There are three continuous slab heating furnaces, each rated at 100 tons per hour. They are 96 ft long overall, and have hearths 80 ft long x 20 ft wide. They are triple-fired with natural gas, coke-oven gas or fuel oil, with six burners above and six burners below in the heating zone and eight burners overfiring the soaking zone. The solid-hearth soaking zone is 17 ft-3¾ in. long.

The furnaces have suspended roofs, using semisilica and superduty fire brick insulated with 2-in. blocks and ½-in. cement. Sidewalls carry 1 in. of insulation; 10 in. of insulation is installed beneath the hearth. The furnaces are steel encased.

Air for combustion comes from a 75,000-cfm fan for each furnace. Air is preheated to a maximum of 900 F in two refractory recuperators on each furnace.

Each firing zone of each furnace is equipped with a fuel input control, fuel-air ratio control and temperature control. Each furnace has a furnace pressure control as well as a pressure recorder, fuel-air ratio indicator and a combination gas-oil recording flow meter.

Maximum fuel input is about 215,000,000 Btu per hr. Fuel consumption averages 2,125,000 Btu per net ton of slabs heated.

Slabs are moved into and through the furnace by a double rack-and-pinion pusher driven by two 100-hp mill type motors. By action of the pusher, a heated slab is expelled from the front end of the furnace on to mill tables approximately 147 ft long leading to the mill.

The first stand of the mill is a two-high scalebreaker, followed by a vertical edger and a four-high reversing rougher. Table VII gives principal data for the mill stands.

In the reversing stand, the top rolls are hydraulically balanced and are moved up and down by 20-in. mill screws operated by two 75-hp mill type motors to give a roll lift of 34.3 in. per min. Maximum roll opening is 14 in.

Roll neck bearings in the scalebreaker are plain bronze; roller bearings are applied to the edger rolls and the rougher work rolls. Back-up rolls in the rougher run in oil-film bearings.

The roughing stand is driven by a twin-drive, with the motors drawing power from a flywheel motor-generator set carrying four 2000-kw, 700-volt d-c generators and a 6000-hp, 6900-volt, 508-rpm induction motor. This is a duplicate of the set serving the reversing slabbing mill.

**Three continuous furnaces, rated at 100 tons per hr each and fired with natural gas, coke-oven gas or fuel oil, heat slabs for the hot strip mill.**

**TABLE VII**
**Strip Mill Data**

| Stand | Diameter, in. | | Roll body length, in. | Distance from preceding stand, ft-in. | Motor data | | | | Gear ratio | Roll, rpm | Roll face speed, fpm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Work roll | Back-up roll | | | Hp | Voltage | Type | Rpm | | | |
| **Hot strip mill** | | | | | | | | | | | |
| Roughing scale breaker | 30 | .. | 100 | ... | 700 | 6900 | a-c | 500 | 35.7 | 13.98 | 110 |
| Vertical edger | 33 | .. | 12 | 35-5½ | 1000 | 700 | d-c | 250/720 | 8.312 | 30/86.4 | 260/750 |
| Reversing rougher | 36 | 54 | 90 | 8-3 | (2) 3500 | 700 | d-c | 40/80 | Direct | 40/80 | 376.2/752.4 |
| No. 1 finisher | 26½ | 53 | 90 | 203-11 | 4000 | 650 | d-c | 190/385 | 5.2 | 36.6/74 | 245/496 |
| No. 2 finisher | 26½ | 53 | 90 | 20-0 | 4000 | 650 | d-c | 190/385 | 3.58 | 53.1/107.5 | 356/721 |
| No. 3 finisher | 26½ | 53 | 90 | 20-0 | 4000 | 650 | d-c | 200/420 | 2.72 | 73.6/154.5 | 492/1035 |
| No. 4 finisher | 26½ | 53 | 90 | 20-0 | 4000 | 650 | d-c | 190/385 | 1.83 | 103/208 | 689/1400 |
| No. 5 finisher | 26½ | 53 | 90 | 20-0 | 2850 | 650 | d-c | 250/490 | 2.1 | 119/234 | 797/1560 |
| **Skin pass mill** | 30 | .. | 90 | ... | 550 | 2300 | a-c | 350 | 10 | 35 | 274 |
| **Tamden cold mill** | | | | | | | | | | | |
| Stand No. 1 | 19 | 52 | 56 | ... | 2500 | 750 | d-c | 144/323 | Direct | 144/323 | 715/1600 |
| Stand No. 2 | 19 | 52 | 56 | 13-0 | (2) 2500 | 750 | d-c | 225/450 | Direct | 225/450 | 1115/2230 |
| Stand No. 2 | 19 | 52 | 56 | 13-0 | (2) 2500 | 750 | d-c | 300/570 | Direct | 300/570 | 1406/2820 |
| Stand No. 4 | 19 | 52 | 56 | 13-0 | (3) 1667 | 750 | d-c | 350/725 | Direct | 350/725 | 1740/3600 |
| Tension reel | ... | .. | ... | ... | (2) 600 | 750 | d-c | 200/700 | | | |
| **Temper mills** | | | | | | | | | | | |
| 48-In. mill | | | | | | | | | | | |
| Entry reel | ... | .. | ... | ... | (2) 75 | 275 | d-c | 565/1695 | ... | ... | ... |
| Entry tension | ... | .. | ... | ... | 75 | 530 | d-c | 160/425 | ... | ... | ... |
| Entry tension | ... | .. | ... | ... | 125 | 530 | d-c | 160/425 | ... | ... | ... |
| No. 1 stand | 9 | 38 | 48 | ... | 500 | 600 | d-c | 177/500 | 1.66 | 106/301 | 1061/2999 |
| No. 2 stand | 27 | .. | 48 | 13-6 | 500 | 600 | d-c | 177/500 | Direct | 177/500 | 1252/3537 |
| Delivery tension | ... | .. | ... | ... | 150 | 650 | d-c | 250/650 | ... | ... | ... |
| Delivery tension | ... | .. | ... | ... | 300 | 650 | d-c | 250/650 | ... | ... | ... |
| Delivery reel | ... | .. | ... | ... | 225 | 327 | d-c | 470/1680 | ... | ... | ... |
| 56-In. mill | | | | | | | | | | | |
| Entry reels | ... | .. | ... | ... | (2) 225 | ... | d-c | ... | ... | ... | ... |
| Mill stand | 17 | 49 | 56 | ... | 1000 | 660 | d-c | 450/900 | Direct | 450/900 | 2000/4000 |
| Delivery tension | ... | .. | ... | ... | 1000 | 660 | d-c | ... | ... | ... | ... |
| Delivery Reel | ... | .. | ... | ... | 600 | 750 | d-c | ... | ... | ... | ... |
| **Sendzimir cold mill** | | | | | | | | | | | |
| Entry reel | ... | .. | ... | ... | (2) 600 | 300 | d-c | 300/1080 | ... | ... | ... |
| Main drive | ... | .. | ... | ... | (2) 2000 | 600 | d-c | 500/700 | ... | ... | 3500 max |
| Discharge reel | ... | .. | ... | ... | (2) 600 | 375 | d-c | 185/835 | ... | ... | ... |

Normally, the two main mill motors are on a common bus fed by three of the generators. Load balance between generators is obtained through cross-connected series fields. Load balance between top and bottom drive motors is obtained through separate motor field load balance windings, excited from a common load balance exciter, which in turn is excited from a load balance pilot exciter which responds to the mill motor differential interpole voltage.

The edger motor has its own individual generator. Speed matching is attained through edger droop control and reduced edger generator voltage control.

The roughing unit is equipped with automatic preset screwdown controls for the horizontal rolls and the vertical edging rolls, and automatic short-travel limit switch control for the front and back side-guides. Two separate schedule panels are provided, each of which can handle as many as 15 passes.

Roughing speeds range up to 752 fpm.

Front and back mill tables on the rougher have rollers 16 in. in diameter. The front table is about 28 ft long and is driven by one 100-hp motor. The back table, about 40 ft long, is driven by two 75-hp motors.

Leaving the rougher, the steel passes over a delay table about 200 ft long leading to the finishing train. Just ahead of the finishing train there is a drum-type crop shear which can be used to even up the strip ends. It is driven by two 150-hp motors under adjustable voltage control. There is also a set of pinch rolls which act as a finishing scalebreaker.

The five finishing stands are four-high units with roller bearings on the work rolls and oil-film bearings on the back-ups. Mill screws on each stand are driven by two 35-hp motors connected by a magnetic clutch. Some details of the finishing stands are given in Table VII.

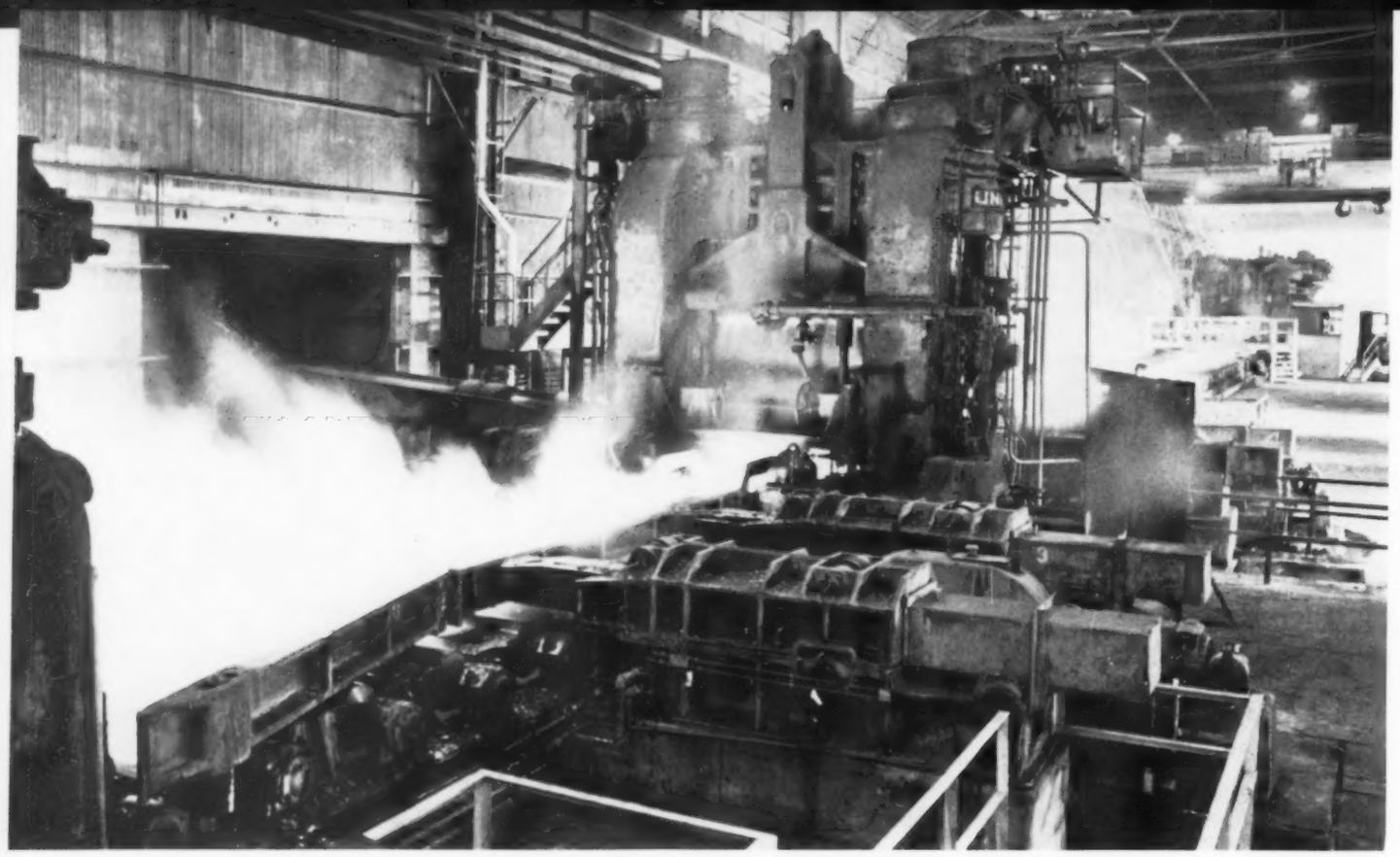
The main drive motors of the finishing train draw power from three duplicate motor-generator sets, each consisting of two 2500-kw, 650-volt d-c generators driven at 514 rpm by a 7200-hp, 6600-volt synchronous motor. These generators feed a common bus which feeds the finishing stand drives.

Power consumption for the hot strip mill and its auxiliaries runs about 70 kwhr per ton.

Motor-operated loopers are provided between the finishing stands to take up slack that may occur in the strip while rolling.

Hydraulic sprays for descaling the strip are located, top and bottom, at the roughing scalebreaker, at the exit side of the reversing rougher and at the entry sides of the first and second finishers. Water is supplied to these sprays by five 7-stage centrifugal pumps rated 600 gpm, 1000 psi each.

Further insurance for strip quality is provided by



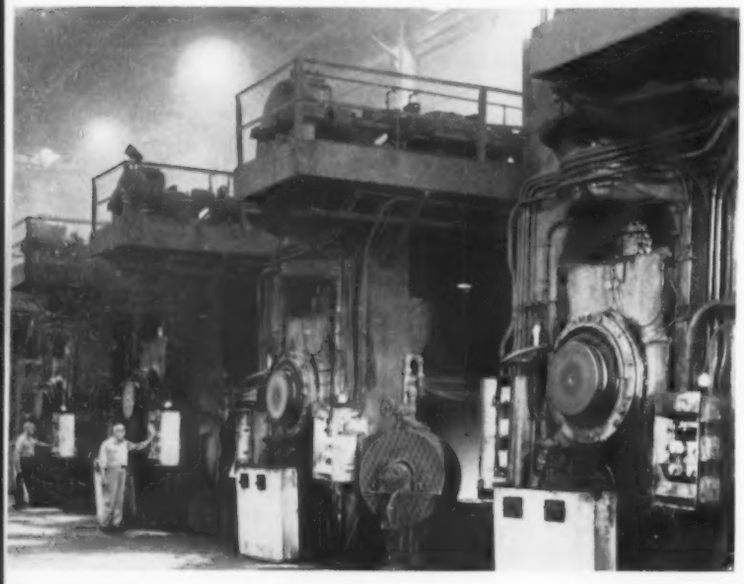
**Hot slabs are roughed down on a 36 in. & 54 in. x 90 in. reversing stand driven by two 3500-hp motors in twin-drive arrangement.**

radiation pyrometers which measure steel temperatures at the crop shear, ahead of the last finisher and at the coilers.

From the finishing train, strip proceeds over a runout table to two up-coilers about 310 ft away. The table consists of 80 rollers 10 in. in diameter on 24-in. centers, each driven by a 3-hp, 900-rpm a-c motor, and 77 rollers 12 in. in diameter on 24-in. centers, each driven by a 3-hp, 700-rpm d-c motor.

The coilers are somewhat different in characteristics. Both have a 30-in. mandrel driven by a 250-hp, 400/1200-rpm, 230-volt d-c motor. However, No. 1 coiler forms coils up to 60 in. O.D. from material up to $\frac{3}{8}$ in. thick and 24 to 64 in. wide. No. 2 coiler will form coils up to 66 in. O.D. from material up to $\frac{1}{2}$ in. thick and 24 to 77 in. wide.

**The strip is finished in this five-stand continuous train which has a maximum exit speed of 1560 fpm.**



The completed coils are ejected on to unloaders which place them on end on a conveyor which moves the coils to an adjacent storage building.

The hot mill is lubricated by 15 circulating oil systems of various sizes, eight automatic grease systems and three manual grease systems.

The hot mill produces 16 gage strip up to 36 in. wide, 14 gage up to 48 in. wide, 12 gage up to 60 in. wide and heavier weights up to 74 in. wide. The over-all rolling rate averages 207 tons per hr, but the mill has turned out as much as 2768 tons in a 8-hr turn and 7365 tons in one day. The monthly production record stands at 114,819 tons.

A typical rolling schedule might show reductions as follows:

*Roughing pass*

| *No.* | *Per cent* |
|---|---|
| 1 | 20–25 |
| 2 | 30–35 |
| 3 | 30–35 |
| 4 | 35–40 |
| 5 | 40–45 |

*Finishing pass*

| *No.* | |
|---|---|
| 1 | 50–55 |
| 2 | 40–45 |
| 3 | 30–35 |
| 4 | 20–25 |
| 5 | 5–10 |

Hot rolled finishing facilities, located in the hot mill building beyond the coilers, includes a 30 x 90-in. skin pass mill (for cut lengths?) and two shear lines. The ¼-in. shear line cuts material 0.0478 to 0.25 in. thick and 24 to 61½ in. wide into lengths of 40 to 390 in. at speeds up to 310 fpm. It processes 55 to 90 tons per hr, depending on the stock weight. The ⅜-in. line cuts materials 0.12 to 0.375 in. thick and 24 to 74 in. wide into lengths of 72 to 700 in. at speeds up to 120 fpm. It produces 20 to 50 tons per hr depending on the material.

## COLD MILLS AND FINISHING

Coils to be cold rolled are moved by underground conveyor from the storage building to the pickling department. Here they are cleaned of all hot mill scale by pickling in a continuous line 621 ft long overall, rated at 55,000 tons per month. The entry end of this line is composed of the conventional feed reel, scale-breaking processor, a shear for trimming coil ends, a flash buttwelder, a flash trimmer, a stitcher, looping pits and pinch rolls.

Next is a hot spray tank, followed by a single, long pickling tank divided into four sections. This tank is fabricated of ⅜-in. steel plate, rubber-lined, with a brick inner lining set in acid resistant cement. The pickling solution runs about 21 per cent by weight of sulphuric acid, and is maintained automatically by steam jets at temperatures of 210 to 235 F. The tanks have steel plate covers, rubber-lined and vented to the outside.

Following the acid tanks are a cold water rinse tank, a hot water rinse tank, a dryer, a side trimmer, an oiler, an upcut shear and an up-coiler.

Speed through the pickling line runs up to 600 fpm in the pickling section and up to 1600 fpm in the entry section.

Pickled coils may be oiled and shipped as hot rolled, pickled material or it may be routed to the cold mill for further reduction.

Cold reduction is performed in a four-stand 56-in. tandem mill with exit speeds up to 3600 fpm. Table VII gives general data on this mill. Work roll necks operate in roller bearings, back-up roll necks in oil-film bearings. Mill screws are driven by two 50-hp motors on each stand.

The main drives of this mill are unusual, due to a rebuilding project whereby the drive power was doubled, using the old motors. No. 1 stand uses one of the old 2500-hp motors. No. 2 and No. 3 stands each have a 5000-hp double armature motor composed of an old 2500-hp motor and a new single-bearing duplicate. No. 4 stand has a 5000-hp, four-bearing triple-armature motor. The tension reel is driven by a 1200-hp, double-armature motor, each armature rated at 375 volts to allow series connection.

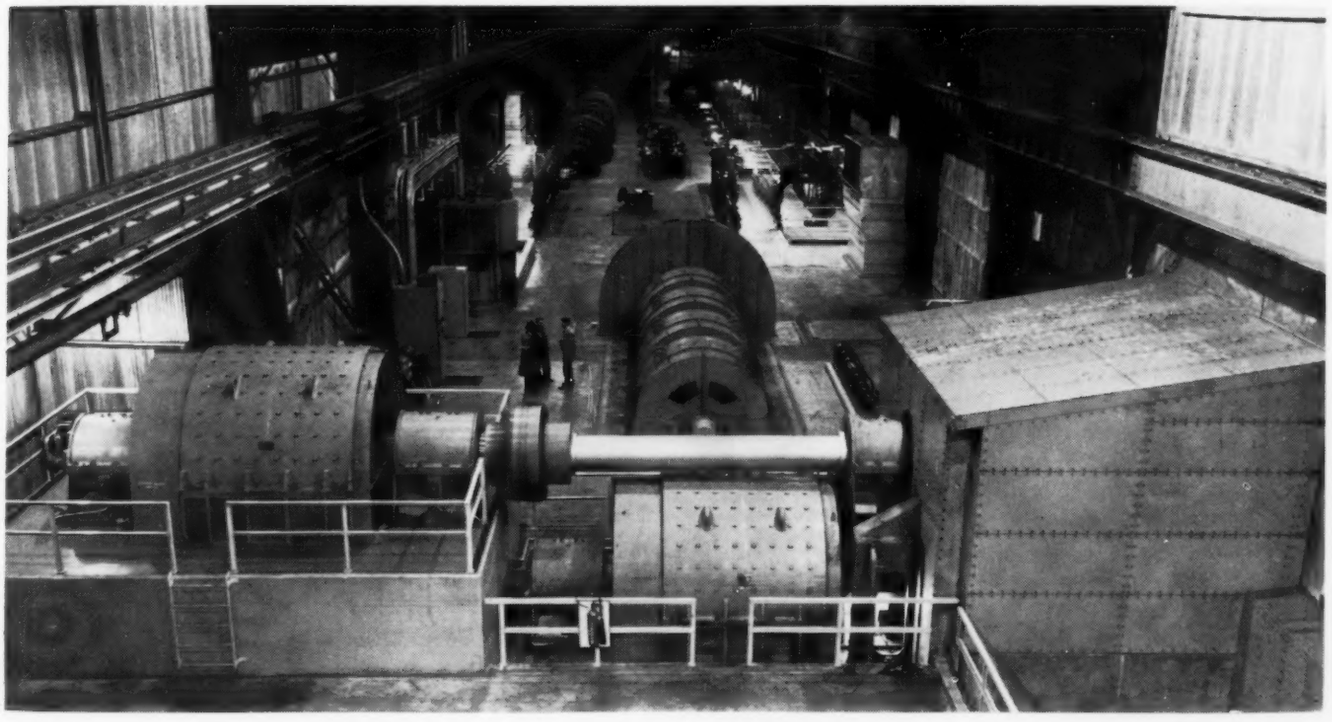
The main drive motors operate under adjustable voltage control, drawing power from two motor generator sets. One set carries four 2000-kw and one 1250-kw generators, all 750-volt d-c, driven by a 12,000-hp synchronous motor. Each 2000-kw generator serves one armature of No. 2 and No. 3 stand drives. The 1250-kw generator serves the tension reel motor. The second set has three 2000-kw generators driven by an 8500-hp synchronous motor. One generator supplies No. 1 stand motor, while the other two supply No. 4 stand drive.

Lubrication for the tandem mill is accomplished through five circulating oil systems and two automatic grease systems.

The tandem mill reduces hot rolled, pickled strip down to gages in the range of 0.0607 to 0.0082 in., in widths up to 48 3/16 in. It has a nominal monthly capacity of 54,000 tons. It was designed to roll 50 tons per hour on tin plate, 95 tons per hour on galvanizing material and 130 tons per hour on sheets.

Nearing completion is a new sendzimir cold mill

**Over-all view of hot strip mill motor room, showing twin drive for the roughing stand in the foreground, finishing drives in background.**



**The two upcoilers differ slightly, with one forming coils up to 60 in. outside diameter, 64 in. wide, the other up to 66 in. outside diameter, 77 in. wide.**

which is to be used to reroll strip from the tandem mill into tin plate gages. This unit has a 1-2-3-4 roll arrangement, using two work rolls of 3½ in. nominal diameter, backed by four 5.42-in. diameter first intermediates. These are in turn backed by six 9.25-in. second intermediates, four of which are driven by the main motor. The second intermediates are backed up by eight rows of 16-in. roller bearings.

This mill is designed to handle coils up to 40,000 lb in weight of 16 or 20 in. inside diameter, 72 in. maximum outside diameter. It will handle cold reduced material 0.015 to 0.02 in. thick and 20 to 40 in. wide, reducing it in one pass to as low as 0.004 in. thickness. Maximum delivery speed is 3500 fpm. Drive data are given in Table VII.

The cold-rolled strip may follow one of three separate paths, depending on whether it is destined to become tin plate, galvanized sheet or cold-finished sheet. For tin plate the next step is to an alkaline cleaning line which handles widths of 23 to 39½ in. at speeds up to 1500 fpm. Entering coils may weigh up to 29,000 lb, exit coils up to 43,000 lb. The line has a monthly capacity of 10,000 tons.

All annealing is at present done by batch furnaces with a total rated capacity of 56,500 tons per month. All furnaces are of the portable cover type. Of these, 18 are single-stack units that will accommodate charges up to 72 in. in diameter x 156 in. high (49 tons). These work at an average rate of 1.6 tons per hour each.

There are three 2-stack furnaces that will take 60-in. coils piled 156 in. high (71 tons). These operate at about two tons per hour each. Seven 4-stack furnaces, with stacks 60 in. in diameter and 156 in. high (147 tons), each turn out 4 to 4.4 tons per hour. There is also a rectangular cover for cut lengths up to 92 x 120 in., piled 74 in. high.

All annealing furnaces are heated with natural gas, consuming 1590 cu ft per ton. Annealing temperatures, automatically controlled, range from 1080 to 1350 F. Cycles run from 19 to 21 hr for the single-stack units to 32 hr for the four-stack units.

Atmosphere gas, to protect the strip surface during annealing, is provided by 12 gas conditioning machines ranging from 4000 to 16,000 cu ft per hr capacity.

Early in 1962, annealing facilities will be expanded with the completion of a 42-in. continuous annealing line that will have a capacity of about 20,000 tons per month. The line will be 375 ft long overall, and will operate at speeds up to 1200 fpm. The strip will be heated to about 1350 F in 18 sec in a natural-gas-fired heating zone, soaked for 24 sec in an electrically heated holding zone, cooled to 900 F in 18 sec in a slow-cooling zone and finally cooled to 150 F in 36 sec in a fast-cooling zone. Protective atmosphere will be 95 per cent nitrogen, 5 per cent hydrogen.

Annealed stock proceeds to the temper mills, where a light reduction, or "skin-pass," is made to impart good surface to the strip and bring it to the desired hardness and stiffness.

Two temper mills are provided, one a two-stand 48-in. unit for tin plate, the other a single-stand 56-in. unit for sheet material. The 48-in. mill has a four-high stand with driven back-up rolls, followed by a two-high stand. It operates at delivery speeds up to 3000 fpm. The 56-in. mill also operates at about 3000 fpm. Details of these mills are given in Table VII.

Cold rolled finishing equipment includes four shearing lines, a trimming line, a leveler line and two resquaring shears.

Coils to be made into tin plate go to two electrolytic tinning lines. The first of these is an alkali line installed in 1942. The second line, completed in 1960, is also of

**Strip is cold reduced in this four-stand 56-in. tandem mill with exit speeds up to 3600 fpm. Production averages about 50 tons per hr.**

alkali type. Some details of these lines follow:

| | *Line A* | *Line B* |
|---|---|---|
| Over-all length, ft-in | 185–6 | 284–6½ |
| Gages handled, in. | 0.0082/0.0125 | 0.003/0.015 |
| Widths handled, in. | 22/32 | 18/38 |
| Speed range, fpm | 200/800 | 300/1200 |
| Tons per hr | 17 | 26 |

Both lines have induction flow brightening units and are equipped with electrostatic oiler, x-ray gage and pinhole detectors.

The combination of the two lines provides a monthly capacity of about 20,000 tons of tin plate.

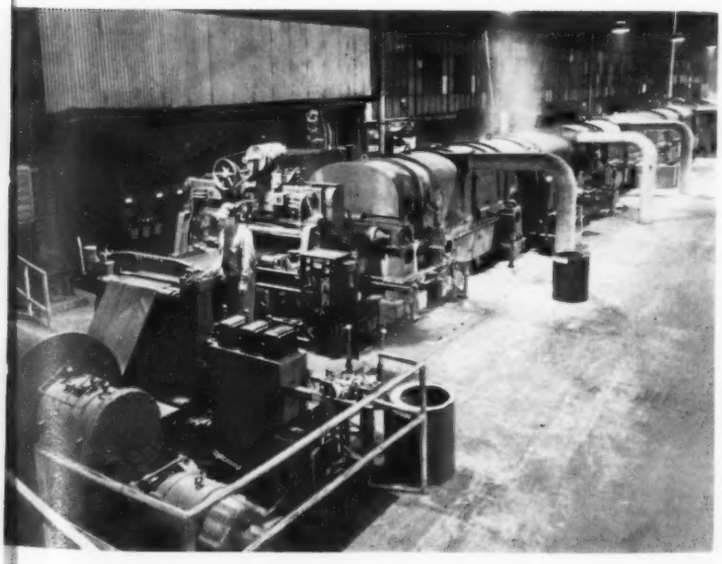
Galvanizing is performed entirely at the North plant adjacent to the main plant. There is one continuous galvanizing line, installed in 1956 and another line is under construction. The present line handles widths up to 48 in. in No. 24 to No. 32 gage. The line, which operates at 50 to 300 fpm, can handle coils up to 20,000 lb in weight. The strip passes from uncoilers through a cleaning section, a preheat furnace with inert gas atmosphere, a galvanizing pot, a cooling section and an inspection section. It is then either recoiled or cut to length.

The line averages about 10 tons an hr. Nominal capacity is 6000 tons per month.

The line under construction will handle widths of 24 to 48 in., thicknesses of No. 8 to No. 32 gage, at speeds up to 450 fpm. This unit will handle coils weighing up to 40,000 lb.

There are also four sheet galvanizing pots, a batch type pickler for cut lengths, a scrubber and dryer, a stretcher leveler, a four-high roller leveler, five corrugating units and a paint line. There is also a continuous roller hearth normalizing furnace, fired with natural gas.

**Cold rolled strip intended for tin plate is put through this alkaline cleaning line to remove rolling oil from the cold rolling operation.**

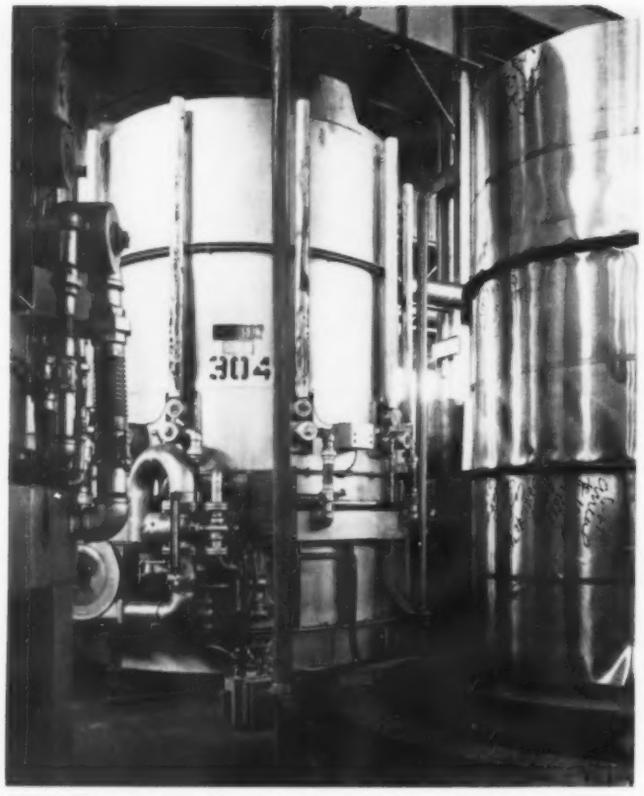


## SERVICES AND UTILITIES

Quality receives the close attention of the entire operating organization. The watch-dogs of these efforts are the metallurgical, chemical and inspection departments. Incoming materials are inspected and checked to insure adherence to specifications. Incoming orders pass through the metallurgical department, where the proper grade of steel and its processing are detailed.

Metallurgical observers watch all phases of the steelmaking and rolling processes to make sure these recommendations are carried out. Inspection carries through from the rolled slab to the finished product ready for shipment. Adequate laboratories are maintained to carry out the entire program of quality control.

In addition to the field maintenance crews assigned




**Single-stack annealing furnaces such as this take charges up to 72 in. in diameter x 156 in. high. Each furnace anneals about 1.6 tons per hr.**

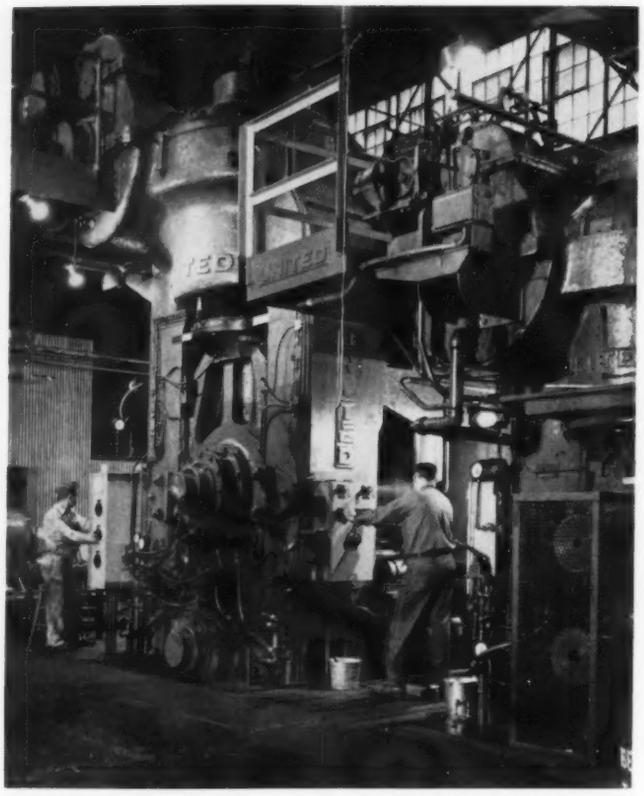
to the various operating departments, a group of shops provide adequate facilities to keep plant equipment operating in good order. These crafts include masons, electric repair, machine, blacksmith, pipe, rigger, carpenter, paint and sheet metal work.

Two roll shops keep the mill rolls in condition. At the hot strip mill these are one 54-in. x 19-ft roll lathe, a 53-in. x 20-ft roll grinder and a 60-in. x 24-ft grinder. At the other shop are five grinders of the following sizes: 14 in. x 6 ft, 20 in. x 12 ft, 28 in. x 12 ft, 40 in. x 18 ft and 14 in. x 8 ft. The last is used to grind rubber rolls.

A mold foundry makes almost all of the ingot molds required in the plant. This foundry is located in the building which formerly housed the old open hearth furnaces which were torn out after the new shop was built.

In a normal month, the plant uses about 24,000,000 kwhr, of which 60 per cent is purchased and 40 per cent generated in the plant. Purchased power comes from the utility company serving the area at 69,000 volts, 60 cycles and passes through a group of 69,000/6900-volt transformers consisting of three 20,000-kva, 3-phase units and three 4000-kva, single-phase units. One 20,000-kva unit is tied into the slabbing mill substation; two are tied to the hot strip substation. The three small transformers are tied to the steel works power house bus.

Power is generated in the plant by seven turbo-generators in two different locations. At the steel plant there are two 7500-kw automatic extracting turbo-generators and two 3000-kw mixed pressure turbo-generators. The former take steam at 400 psi, with extraction at 140 psi for miscellaneous plant usage and, when needed, for the 3000-kw units.

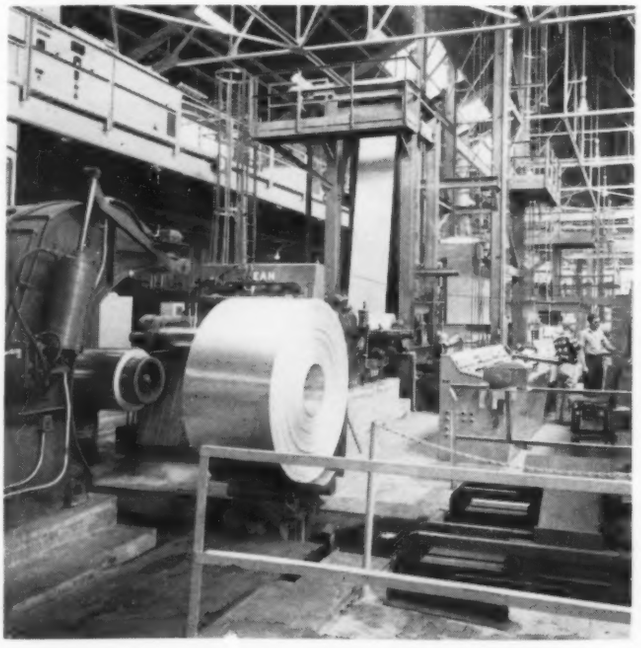


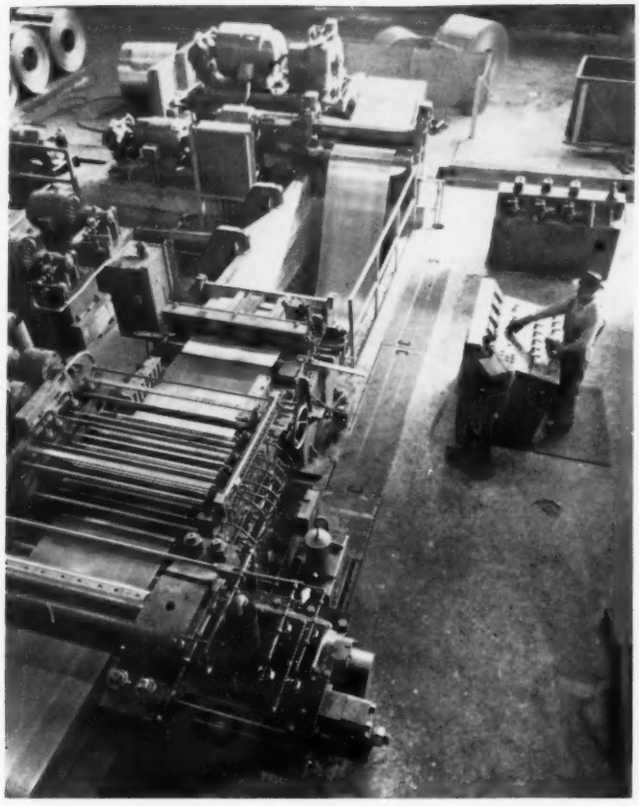
**This two-stand 48-in. temper mill is used for tin plate material after annealing. It makes a light reduction to impart some stiffness and improve surface and flatness.**

The 7500-kw units are equipped with 8000-sq ft surface condensers, adequate to allow operation of the turbines as nonextracting units at full rated load. Condenser water is circulated over a forced draft cooling tower. The 3000-kw units exhaust into barometric condensers which are supplied with water from a spray pond.

The 3000-kw units generate three-phase power at 2300 volts, the 7500-kw units at 6900 volts. The buses

**This recently completed electrolytic tinning line operates at delivery speeds up to 1200 fpm. With an older line, it provides a total capacity of about 20,000 tons of tin plate per month.**





**Entry end of cold strip shearing line. Cold strip finishing equipment includes four lines similar to this.**

are tied together through three 2500-kva, 6900/2300-volt single-phase transformers, so that all generators may be operated in parallel.

Steam for the steel works installation comes from four steam generators rated at 100,000 lb per hr each and operating at 400-psi pressure, 650-F total steam temperature. They are fired with pulverized coal, coke-oven gas and natural gas, and are equipped with superheaters, water walls, air preheaters and economizers.

In the blast furnace power plant No. 1 there are three 5000-kw, 2300-volt turbogenerators equipped with barometric condensers. These units provide power for the coke plant and both blast furnaces, with excess going to the steel works via the utility system, with which both company generating plants operate in parallel. They draw steam from ten 800-hp bent tube boilers which operate at 210-psi, 450-F total temperature. Fuel here is blast furnace gas, coke-oven gas, natural gas or fuel oil. The three small turboblowers are also installed here, two of 40,000 and one of 50,000 cfm capacity.

In the blast furnace power plant No. 2, there is no power generation but there is one 150,000-lb per hr, 250-psi, 500-F steam generator which serves a 125,000-cfm turboblower.

The steel works has a power load running up to 60,000-kw peaks. The blast furnace department load runs about 5000 to 6000-kw peaks. Demand on the utility system ranges from 25,000 to 30,000 kva, and that supplied by the company's plants from 20,000 to 25,000 kva.

Water for general plant use is drawn from a navigation canal paralleling the Mississippi river, about three miles away. Three 27,000,000-gal per day pumps push the water through a 54-in. concrete low-pressure closed conduit to a 10,000,000-gal concrete reservoir at the plant. Chlorine is introduced at the pumps once a week to prevent algae growth in the main. From the reservoir, 12 pumps ranging 1,500,000 to 20,000,000 gal per day distribute the water through the steel plant and blast furnace systems.

At the steel plant, approximately 540,000 gal of water per day is softened by hot lime-soda process for boiler feed (50 per cent make-up) and for certain sheet finishing operations. Boiler feed at the blast furnace consists of 1,320,000 gal per day (75 per cent make-up), treated by cold lime and zeolite processes.

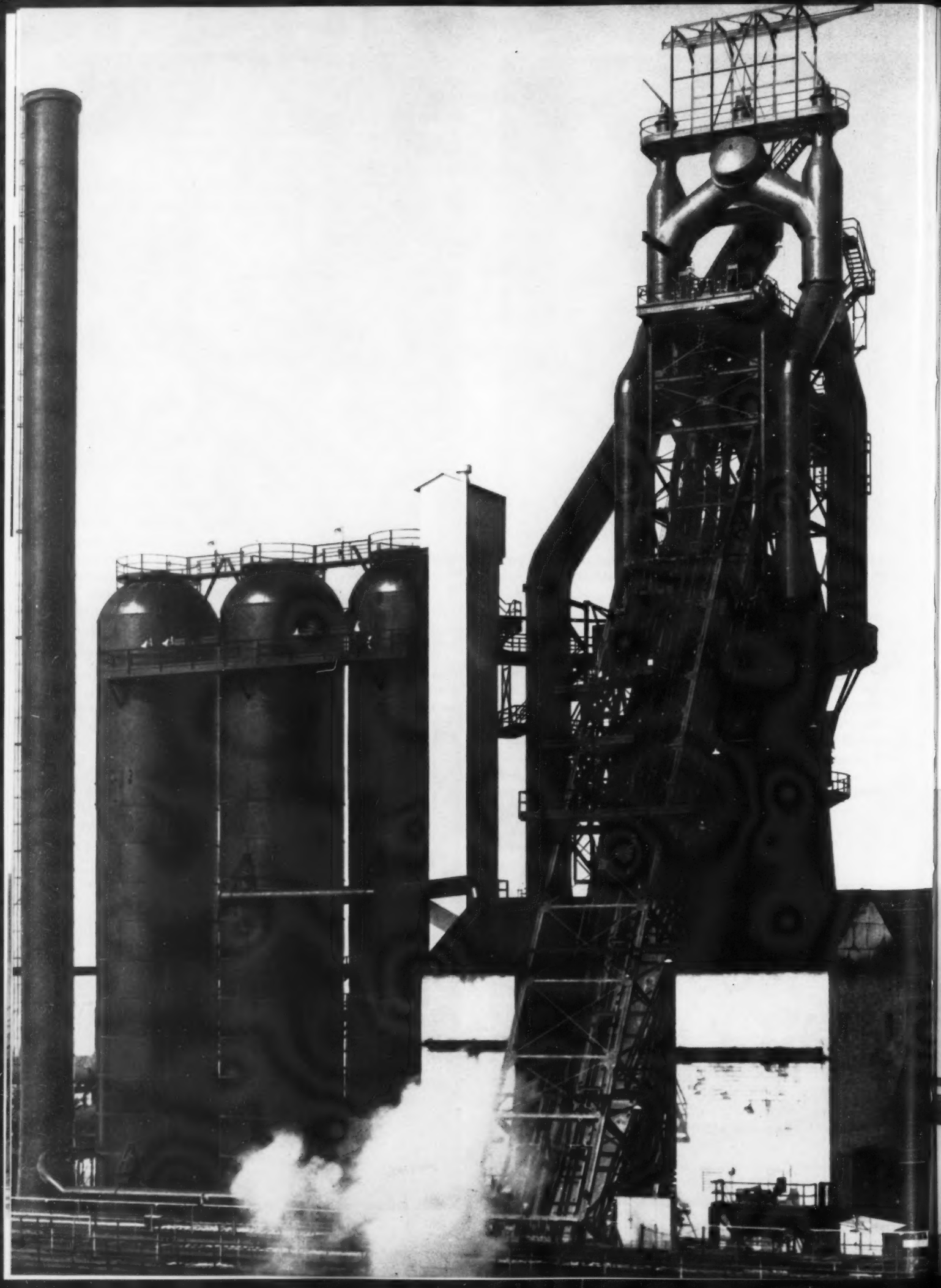
* * *

The foregoing points up the rapid postwar development of Granite City Steel from a small marginal unit into an integrated, efficient producer of flat-rolled products, with an increase in capacity of 155 per cent over its 1948 capacity of 620,000 tons per year.

It also manufactures a line of steel products for the construction industry which are marketed through a subsidiary, Granco Steel Products Co.

Granite City Steel customers are, for the most part, close to home. More than one third of its products goes to users in the six-county St. Louis area. More than 55 per cent is shipped to manufacturers in Missouri and Illinois, and more than 90 per cent to a belt of mid-west states extending from Minnesota to the Gulf of Mexico. Since 1955, the company has enjoyed an operating rate well above the average of the industry, and net earnings represent a somewhat larger slice of the sales dollar. The company employs about 5000 people at full operation and is a major industrial force in its area.

**This corrugator, with rolls 21.5 ft long, is located at the company's North plant.**



# For blast furnaces . . . for coke ovens . . .

# GRANITE CITY called on KOPPERS

Koppers Engineering and Construction Division has a key role in the current expansion program at Granite City Steel Company. Two major steps in the program are this recently completed blast furnace "B" and a new battery of coke ovens now under construction.

Blast furnace "B" was built on a steel platform 87½ feet away from the furnace it had to replace. Koppers built it there so the old furnace could still produce without interruption. Then, the old furnace was torn down and the new one rolled in and set on the old foundation. A 30-man crew did the whole moving job in one hour and 40 minutes. A similar type of operation was carried out in 1956 when the 1,200-ton capacity blast furnace "A" was rebuilt off-site by Koppers and then moved into final position. The new furnace "B" can produce about 1,800 tons of pig iron per day—twice the capacity of the old one.

Koppers is also increasing the coke capacity at Granite City with a new battery of 61 Koppers-Becker gun flue-type coke ovens, and they are enlarging and modernizing sections of the coal chemical recovery operation. With the addition of these 61 ovens, Granite City will have 137 coke ovens—all designed and built by Koppers. The entire expansion program will boost Granite City's production 20% by 1962.

Koppers offers complete engineering and construction service in *any* phase of steel mill operation. Contact Koppers Company, Inc., Engineering and Construction Division, Pittsburgh 19, Pa.

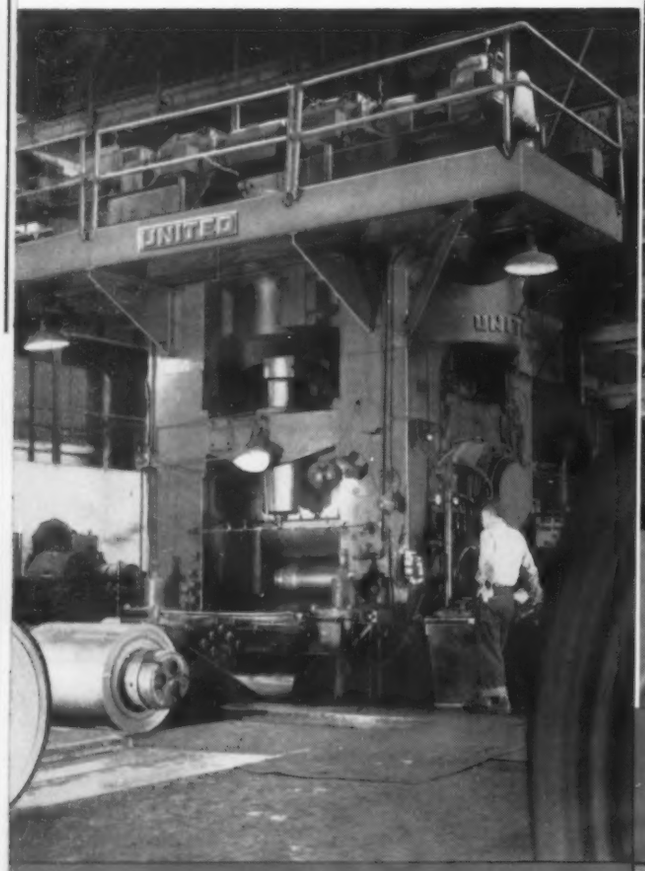
KOPPERS ®

**ENGINEERING and CONSTRUCTION**

ALL COKE OVENS BUILT BY KOPPERS. Shown in the foreground are the 49-oven battery installed in 1942 and the 27-oven battery added in 1953. A new 61-oven battery is now being built under the shed shown at the far left.

1901 UEC 1961

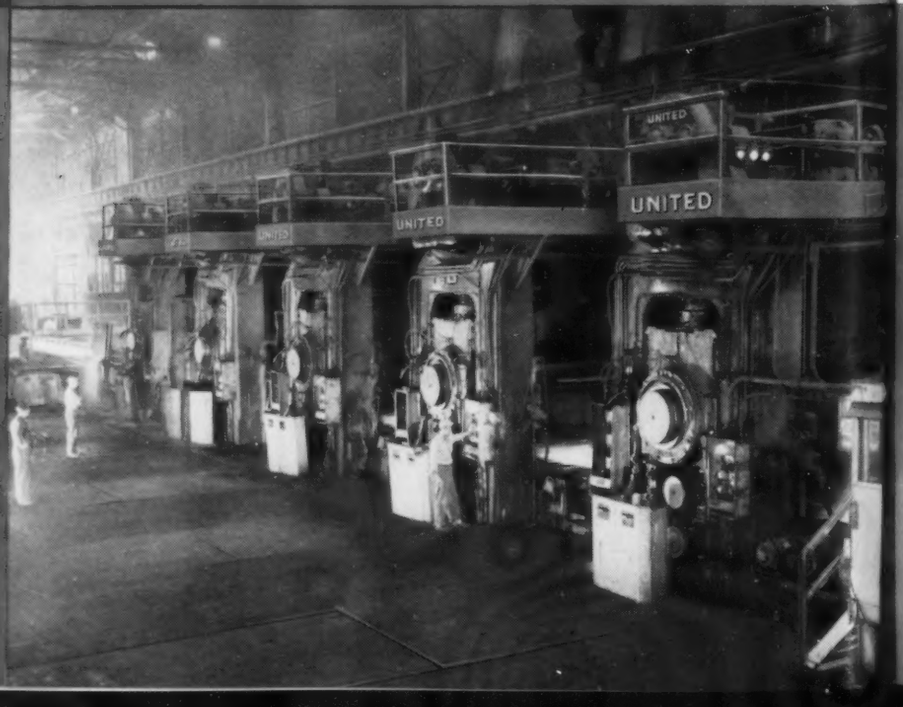
*Progress...Leadership*
*United for Sixty Years*




4-High Temper Mill

45" x 115" Slabbing Mill

26½" and 53" x 90"—5-Stand
Hot Mill Finishing Train



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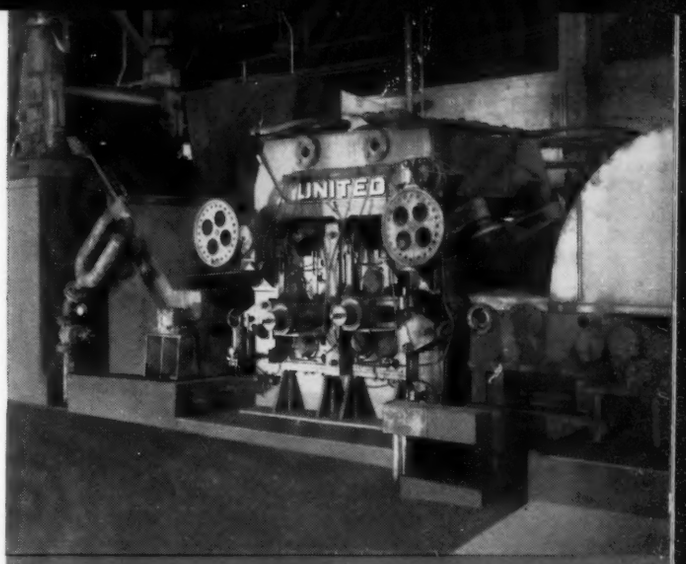
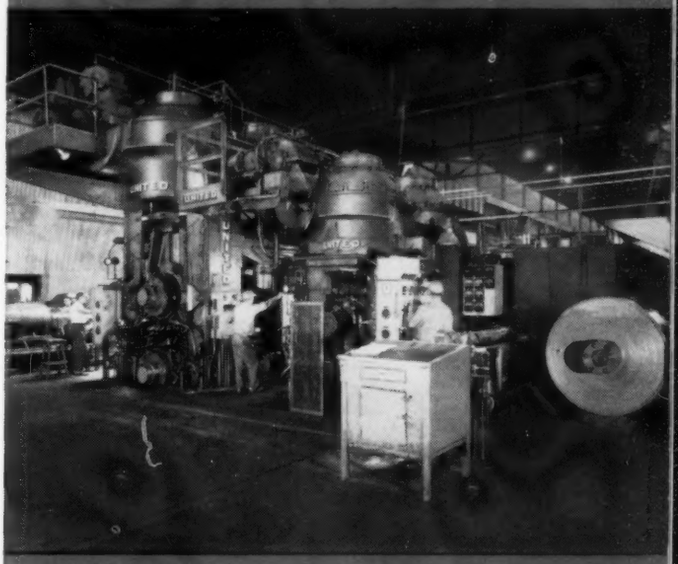



Processing Scale Breaker



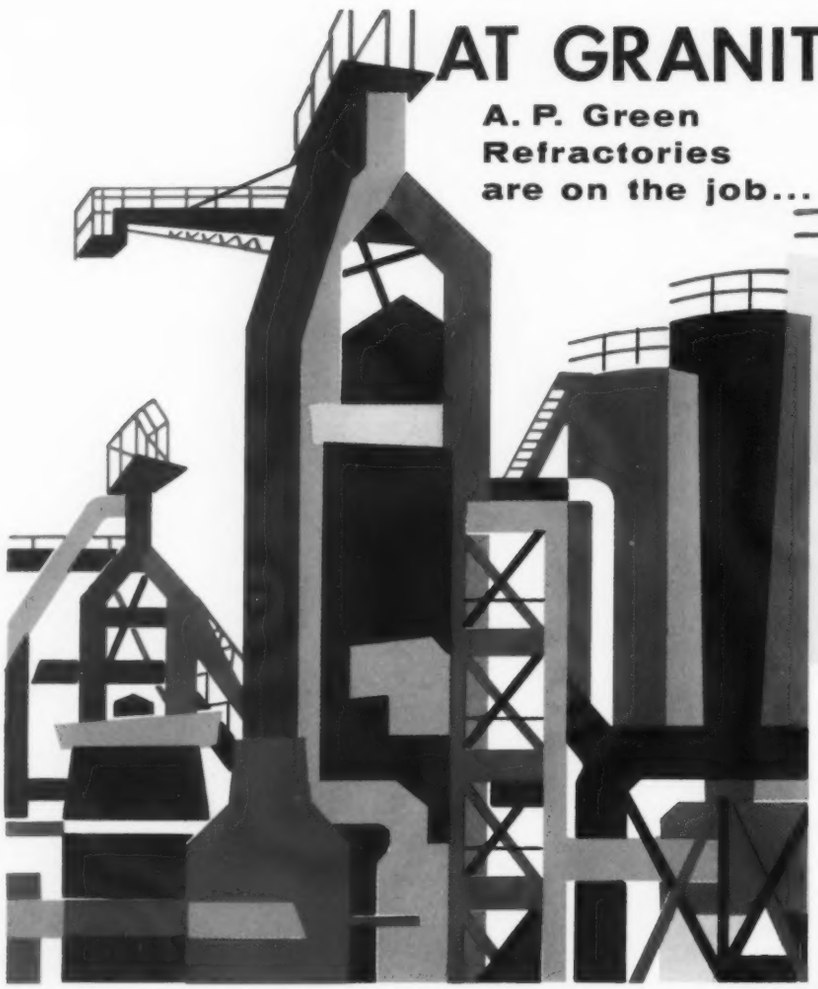
2-Stand Tandem Temper Mill

Hot Strip Mill Flying Shear

Hot Strip Mill Mandrel Type Coilers

# AT GRANITE CITY STEEL...

**A. P. Green Refractories are on the job...**



## Meeting the exacting requirements of steel production

The new "B" blast furnace at Grantic City Steel Company, Granite City, Illinois, is lined with A. P. Green high-fired KX-99 Super-duty refractory brick. Throughout the various iron and steel making operations at Granite City Steel, A. P. Green refractories are *on the job*. A. P. Green materials in blast furnaces, blast furnace stoves, hot metal transfer cars, open hearth roofs, and slab heating furnaces contribute to Granite City Steel's production of quality flat rolled products that make them the "Steelmakers to Middle America."

The Green Company manufactures a complete line of highest quality refractories for all phases of iron and steel plant production. Developed and improved over the years to increase lining life and reduce refractory costs in the Steel Industry, A. P. Green refractories are specified by the leading steel companies of North America and overseas.

For detailed information on service and specific recommendations—contact your local A. P. Green representative or write

A. P. Green REFRACTORY PRODUCTS

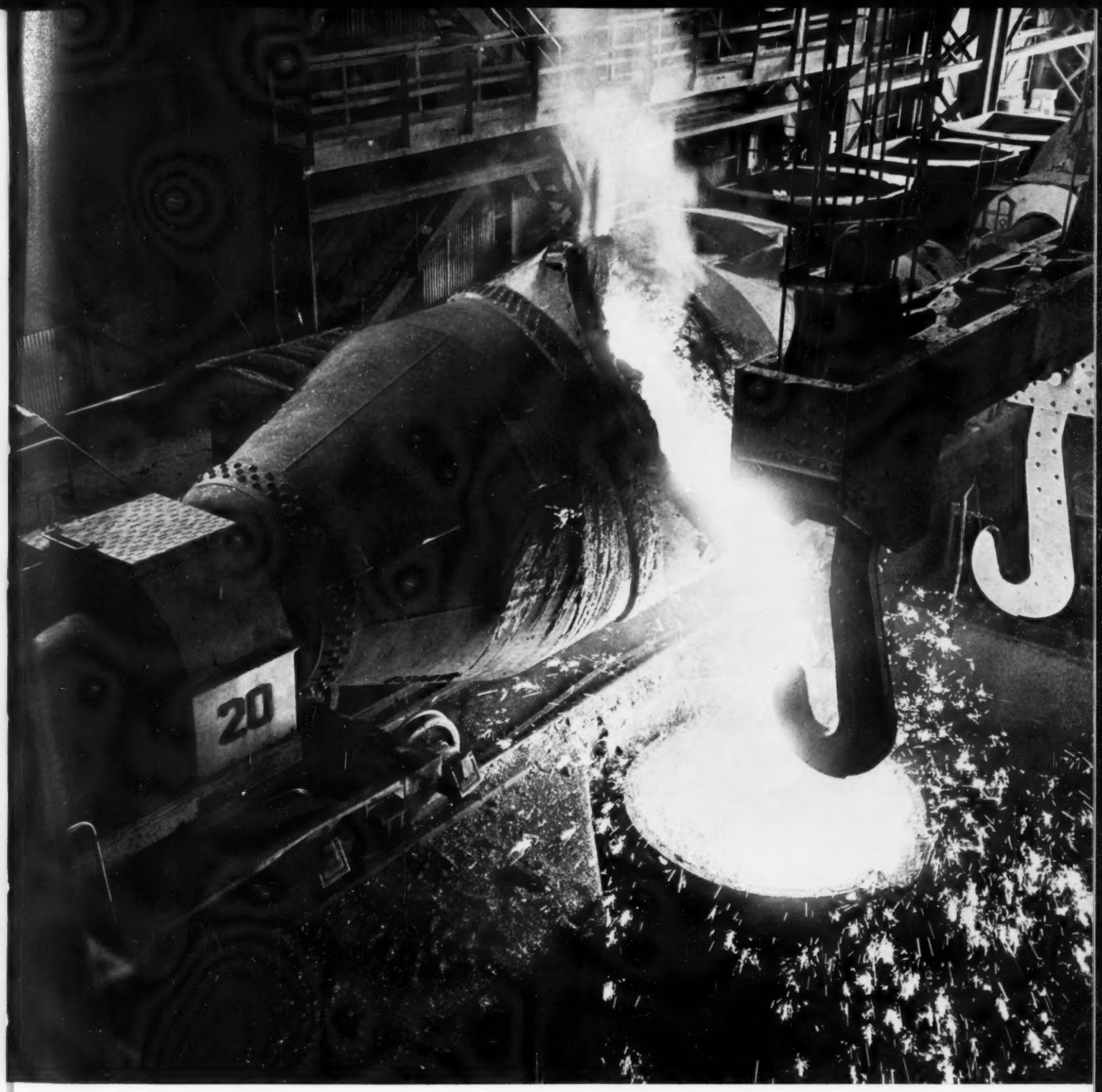
SERVE THE WORLD'S INDUSTRIES

**A. P. GREEN FIRE BRICK CO.**

MEXICO, MISSOURI, U. S. A.

**PLANTS:** Mexico, Mo. - Woodbridge, N. J. - Sulphur Springs, Texas - Jackson, Oak Hill, South Webster, Ohio - Climax, Tarentum, Philadelphia, Pa. - Troy, Idaho - Pueblo, Colo. Macon, Ga. - Birmingham, Ala.

**IN CANADA:** A. P. Green Fire Brick Company, Ltd. (Weston) Toronto, Ontario




# POLLOCK HANDLES THE "HOT STUFF"

***AT GRANITE CITY STEEL COMPANY,*** heat after heat, day after day, Pollock hot metal cars shuttle from blast furnace to open hearth and back. Routine? Certainly! That's the way it should be. A breakdown means slowdown — or shutdown. Dependable Pollock hot metal handling equipment does the job efficiently, unobtrusively—as it was designed to do.

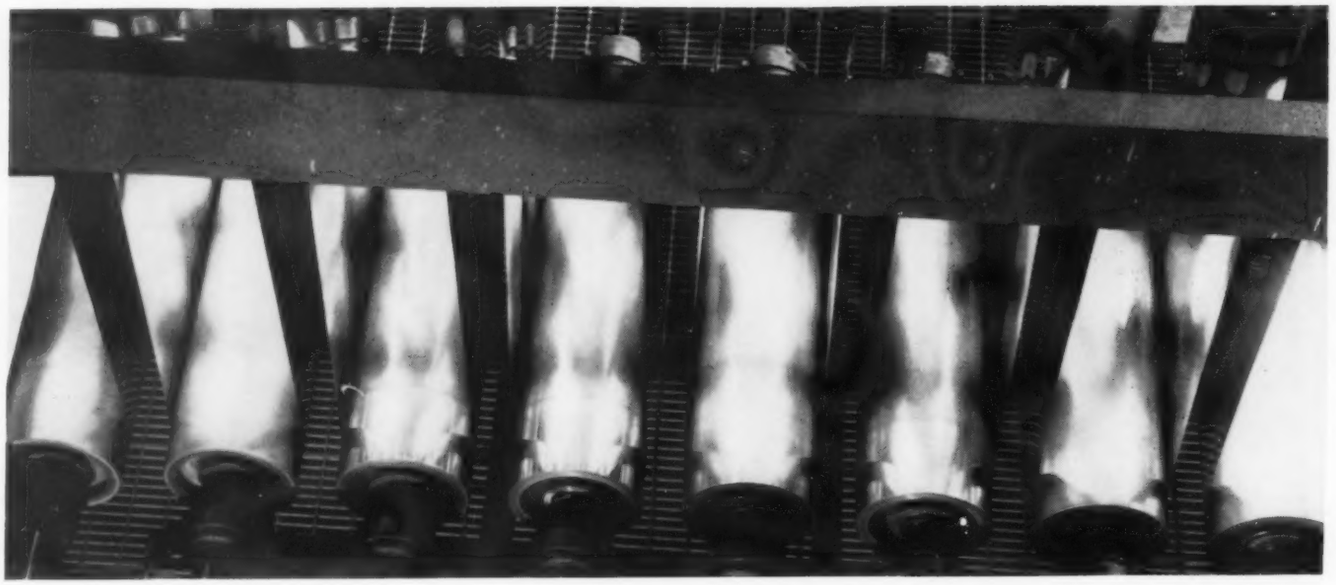
***The Pollock Box Score at Granite City:*** 6-200-ton hot metal cars • 6-400-cu.-ft. slag cars • 5-320-cu.-ft. cinder cars • 7-250-ton open hearth ladles • 5-285-ton open hearth ladles

POLLOCK
SINCE 1863

**THE WILLIAM B. POLLOCK COMPANY**
**YOUNGSTOWN, OHIO**

*Associated in Great Britain with Ashmore, Benson, Pease & Co.*

ENGINEERS, FABRICATORS AND ERECTORS OF BLAST FURNACE STEEL WORK . . .
HOT METAL AND SLAG HANDLING EQUIPMENT FOR . . . BLAST FURNACE, OPEN HEARTH AND ELECTRIC FURNACE PLANTS



Look into the looping tower pit—12½" D x 46" F exit rolls are CRODON-plated to prevent metal pickup, to remain clean and to avoid marking of the sheet. Eight top and eight bottom rolls of the tower are protected by CRODON-plate.

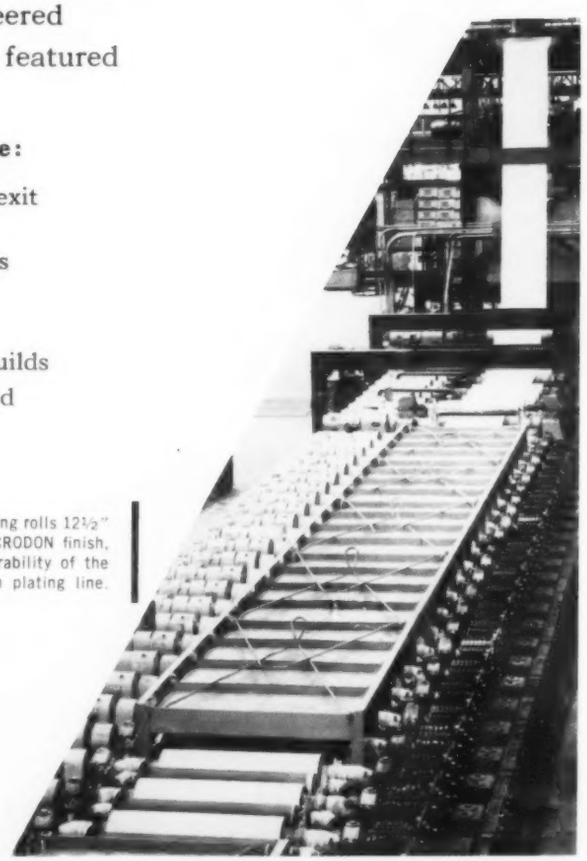
# at Granite City Steel Company

**Performance** of CRODON finishes on rolls of the original tin line led to the same competently-engineered finishes used upon rolls for the new tin line featured in this publication.

**CRODON-plated parts of the two lines include:**

- Grounding rolls
- Current carrying rolls
- Hydraulic rods
- Up-coiler rolls
- Looper rolls, exit
- Pinch rolls
- Deflector rolls

In total, 56 rolls are CRODON-plated. Chromium builds endurance; to this, the superb CRODON finishes add performance at its best. To have these benefits for your mill, start by writing to us.



35 current carrying rolls 12½" D x 48" F, ±3 CRODON finish, add to the durability of the main plating line.

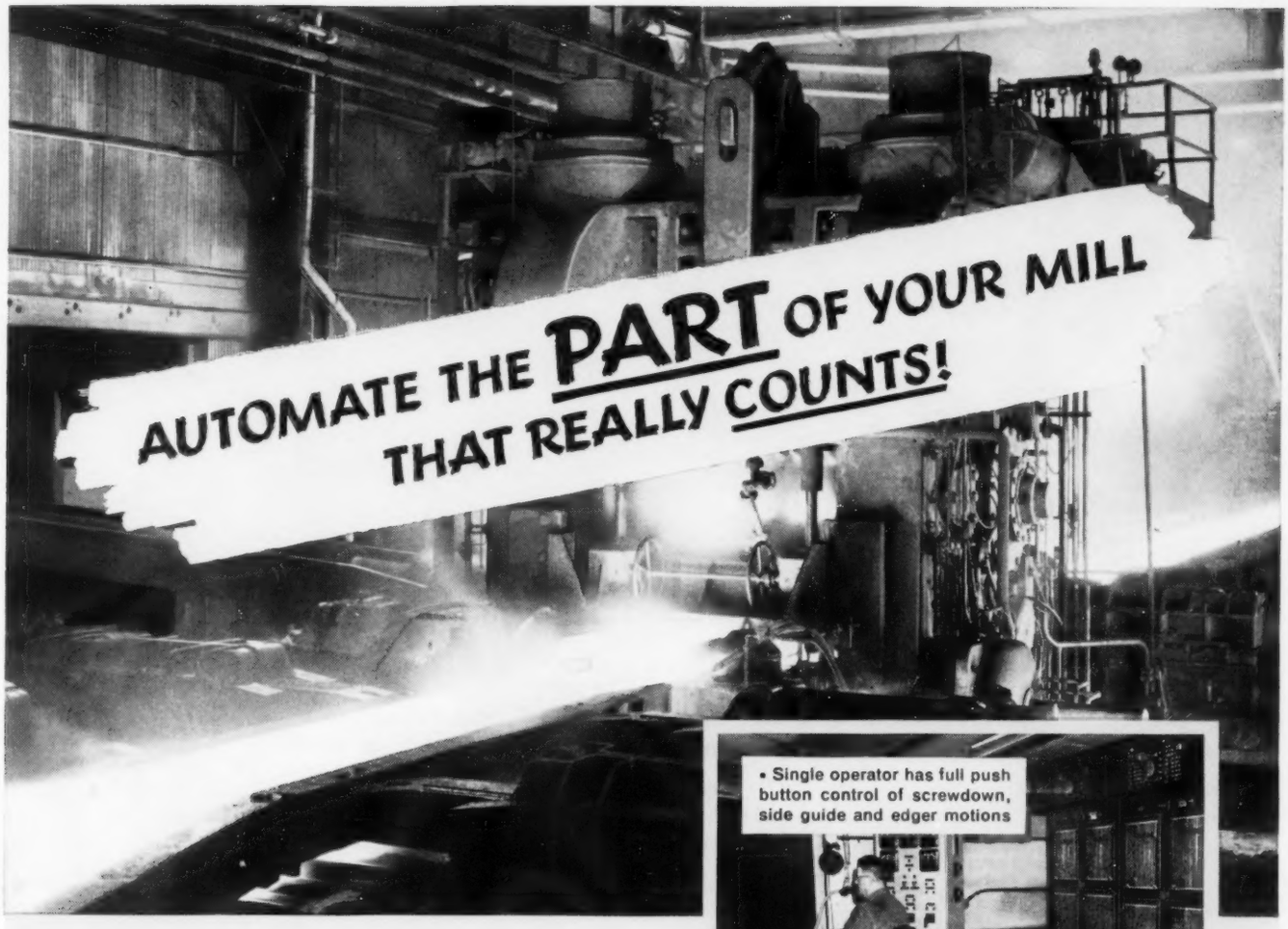
CRODON
*The Chrome Plate*

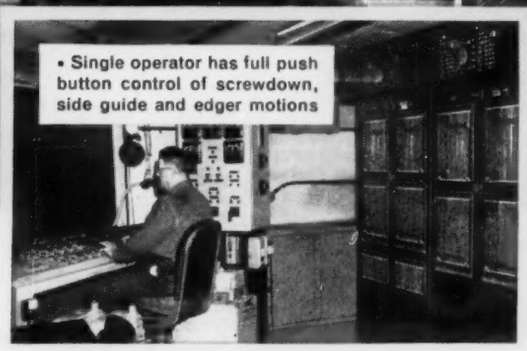
**CHROMIUM CORPORATION of AMERICA**

Engineering, Sales, Plating Plants for Steel Mill Equipment:

**4645 West Chicago Avenue**
**Chicago 51, Ill.**

**346 Huntingdon Avenue**
**Waterbury 20, Conn.**




## You can cut initial investment in HALF -- save on maintenance, too!

Is complete automation of your mill really necessary? EC&M has built automatic screwdown systems for dozens of existing mills, which are giving excellent results at low cost. We are continuing to supply systems which improve results with just one operator in the pulpit.

With the EC&M method, a single push button positions screwdown, side guides and edgers automatically for each pass. No need to memorize rolling schedules...no inaccurate roll settings... the roller's task is greatly simplified. Better quality of rolled product is assured with equal or better output at a low initial expenditure—less than half the cost of completely automating all mill movements. Moreover, the regular maintenance crew can do all servicing...no special personnel training or extra manpower needed.

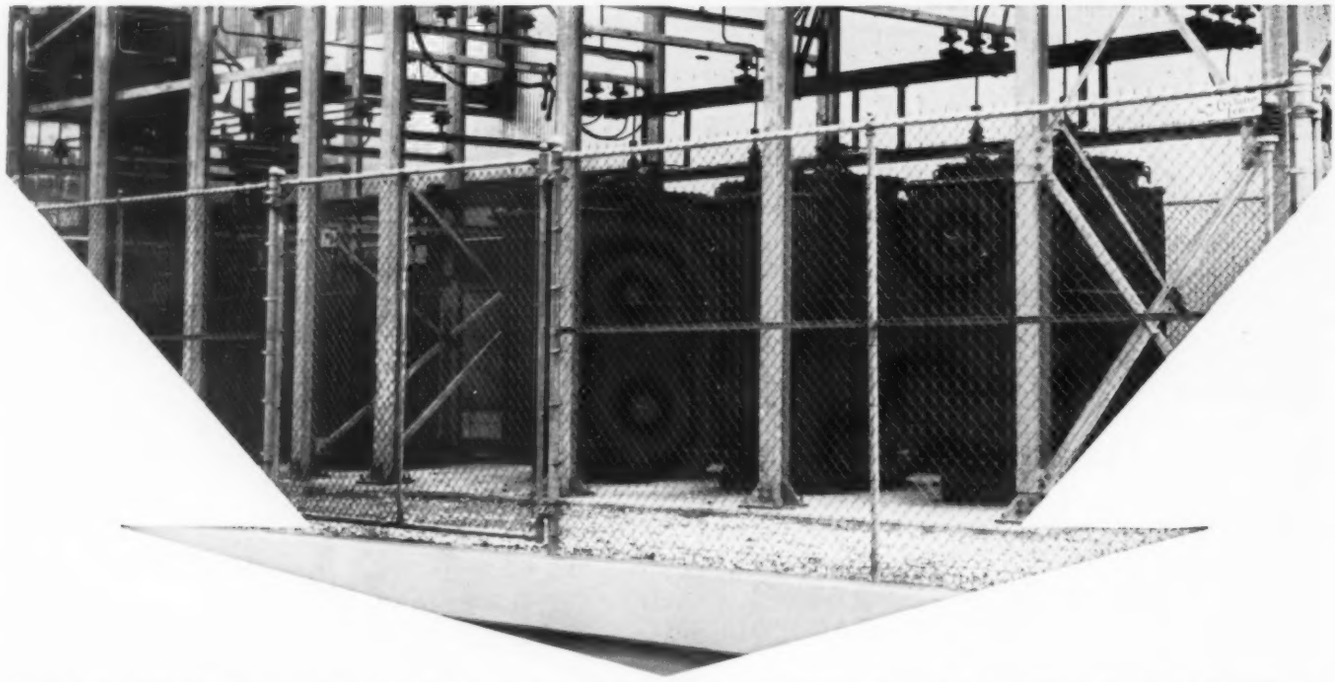
EC&M Engineers will be glad to study your requirements and recommend the equipment required to give effective results, economically.

**7 years of successful rolling at Granite City Steel**
Since it was installed at Granite City Steel seven years ago, the EC&M automatic screwdown system shown above has maintained consistent high quality and output. A single roller operates all motions of this mill, and his efficiency stays at a peak throughout a turn. There is less operator fatigue, physical or mental. In seven years, there have been no production bottlenecks, no delays.

*Write* **FOR DETAILS • Ask for Bulletin & Progress Report 6550. Square D Company, EC&M Division, 4500 Lee Road, Cleveland 28, Ohio**

**SQUARE D COMPANY**
**EC&M DIVISION • CLEVELAND 28, OHIO**
***wherever electricity is distributed and controlled***

6280



## SIX WAGNER® TRANSFORMERS PROVIDE THE POWER

Here are six Wagner® transformers with a full-time job: providing all the power needed by a new electroplating line that produces tin plate for Granite City Steel Company.

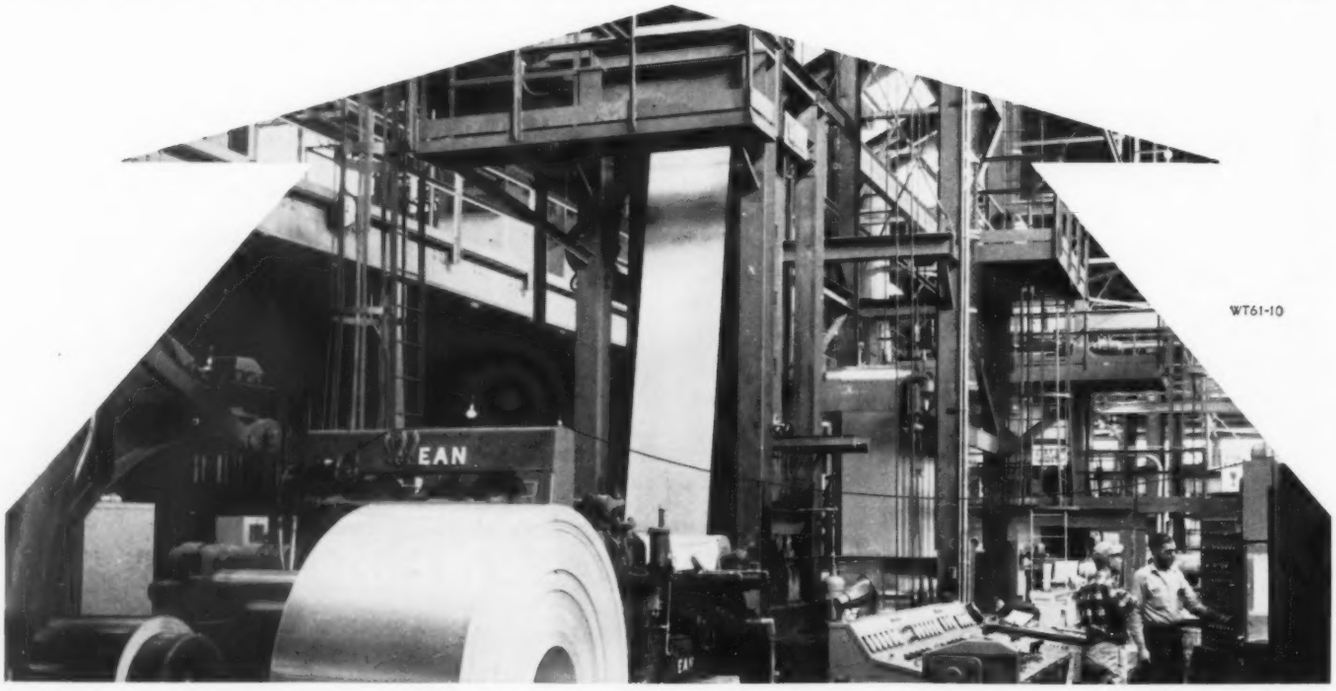
Three of the six supply power to motor-generator sets which convert to DC for variable speed drives, and to plating generation equipment and other major equipment drives. They are all 1667 kva, single phase, 60 cycles, 7200/12470Y to 2400/4160Y volts transformers.

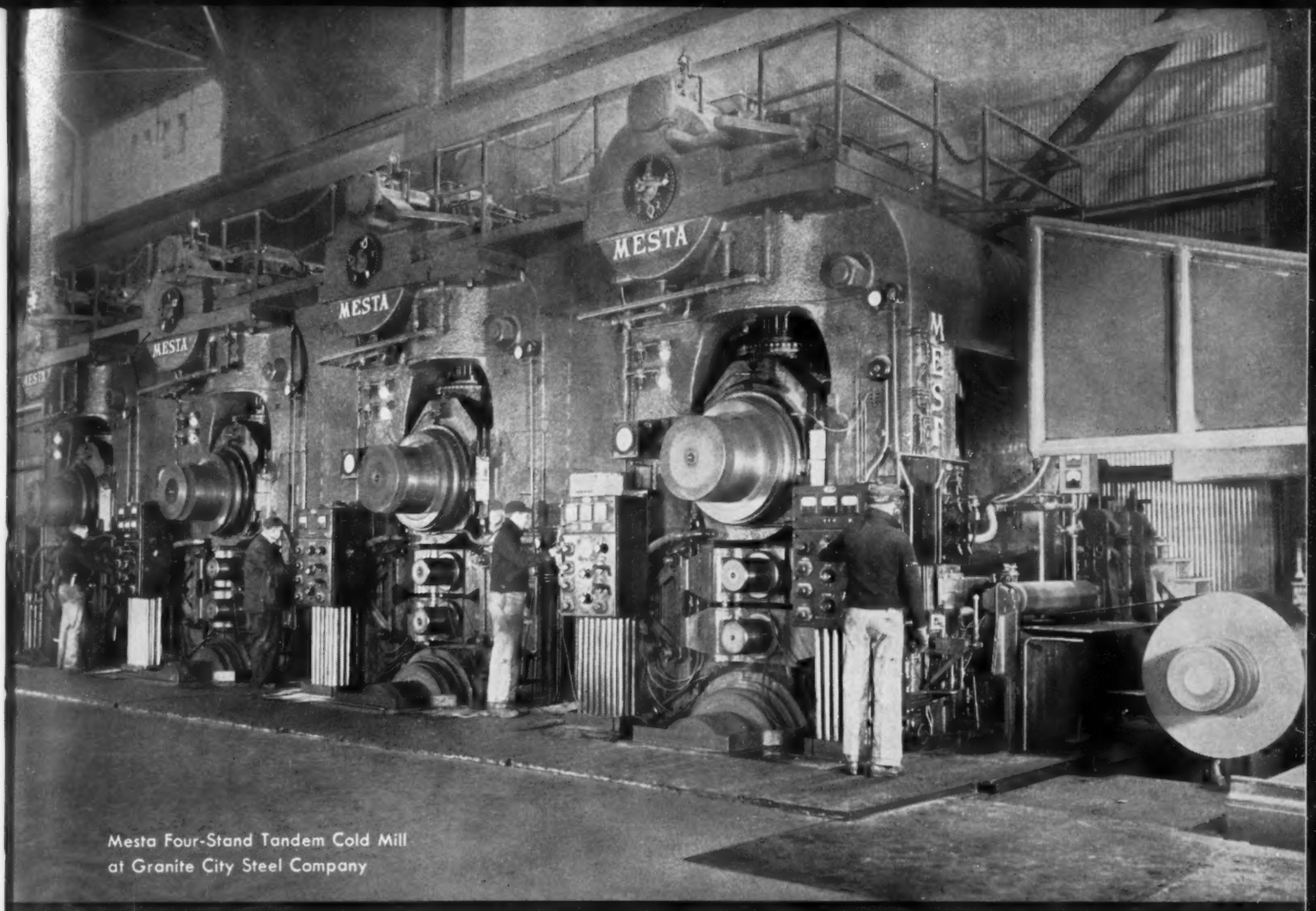
The second set of three transformers are all 500 kva, single phase, 60 cycles, 7200/12470Y to 240 x 480 volts. They supply power for auxiliary pumps, etc.

All six are of the latest design . . . have wound cores of cold-rolled oriented grain steel. Their performance stability is outstanding. They're built to be trouble-free . . . built to provide all the power the plating line needs. Wagner transformers are designed to provide all the power you need, too. Your Wagner Sales Engineer can show you how. Call him. Soon.

**Wagner Electric Corporation**
6483 PLYMOUTH AVENUE, ST. LOUIS 33, MO., U.S.A.

## FOR GRANITE CITY STEEL'S NEW TIN PLATING LINE



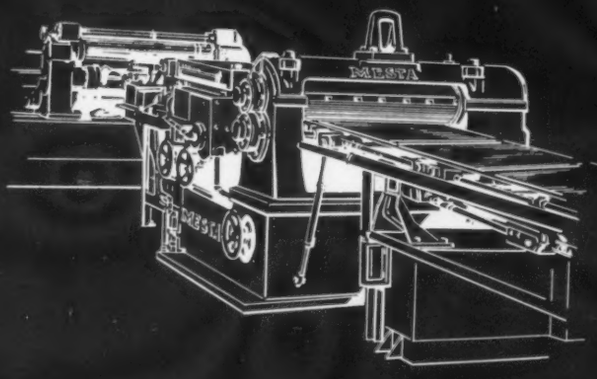



Mesta Four-Stand Tandem Cold Mill
at Granite City Steel Company

# COLD MILLS

*designed and built by*

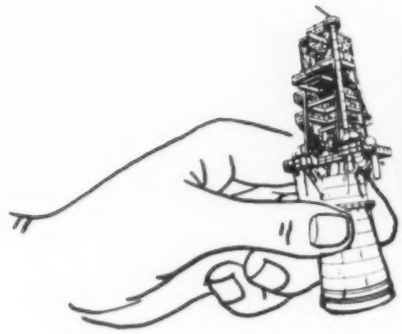
# MESTA




*Designers and Builders of Complete Steel Plants*

**MESTA MACHINE COMPANY**

**PITTSBURGH, PENNSYLVANIA**



# 1800 Ton Capacity BLAST FURNACE Built OFF-SITE AT Granite City Steel

Designed and built by the Freyn Department of Koppers, the new blast furnace was constructed on a 38-foot-high steel platform while the old furnace remained in operation. This off-site operation saved nearly 6 weeks "down-time".

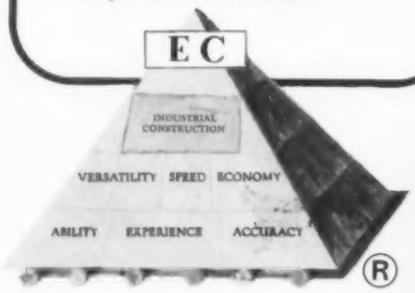
It took less than 2 hours to move the furnace shell 87½ feet. After that less than 12 hours were required to lower the furnace shell 3 feet 4½ inches on to the nine furnace columns.

This is the second furnace built "off-site" at Granite City—the first was in 1956 and the second in 1960.

This operation has been performed five times in the steel industry—and Eichleay has moved all five.

**EICHLEAY SERVICES**

**Industrial Machinery Installations**
**Construction of Heavy Foundations**
**Building and Machinery Moving**
**Complete Industrial Plants**




Eichleay's success in the handling of modernization of old and construction of new projects is due largely to careful, painstaking planning.

# Eichleay

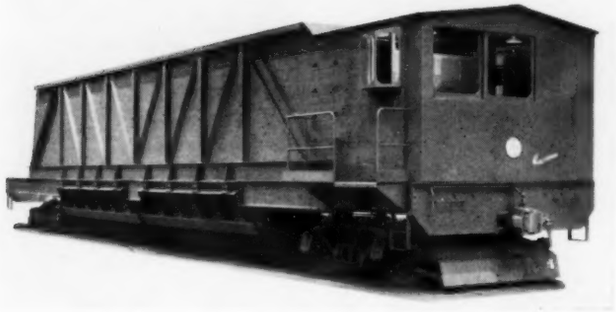
CORPORATION

33 South 19th St., Pittsburgh 3, Pa.
1180 Richard Ave., Santa Clara, Calif.
11919 Avenue O, Chicago 17, Ill.
Eichleay Corporation International, Canada

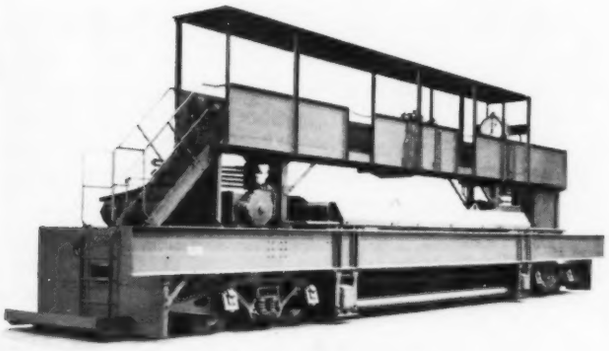
# serving GRANITE CITY STEEL

# ATLAS CARS

60-Ton Side Dump Ore Transfer



45-Ton Gable Bottom Coke Transfer



45-Ton Bottom Dump Scale Car

**Atlas steel plant equipment like these cars in use at Granite City are highly regarded for their dependability and low maintenance.**

## the ATLAS Car & Mfg. Co.

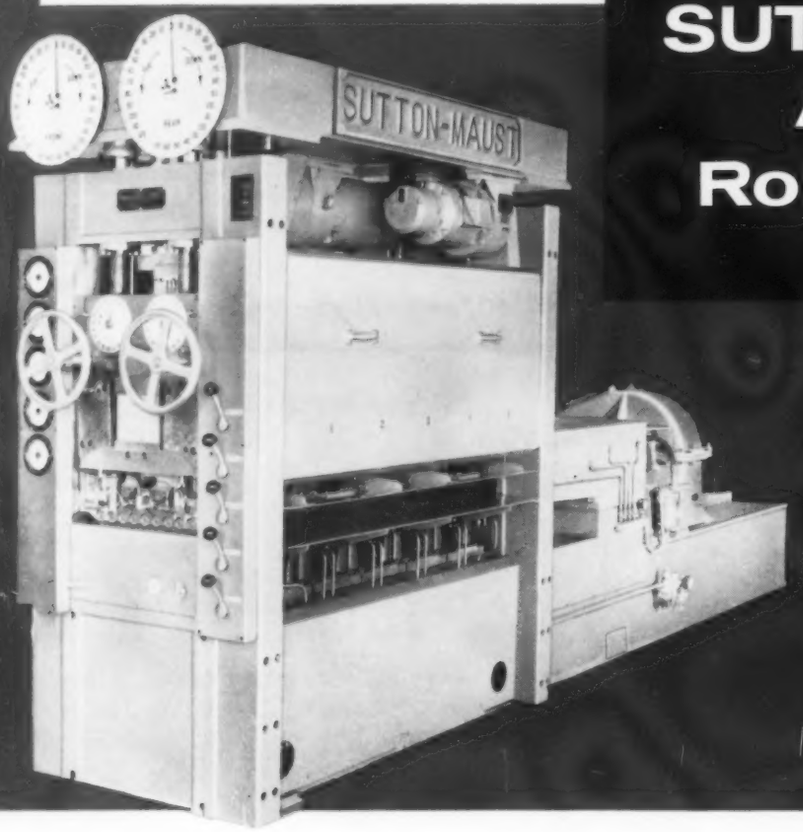
**1100 Ivanhoe Rd.** **Cleveland 10, O.**

# Maximum flattening efficiency

for sheets, plate and strip in all metals

INCLUDING TENSION LEVELING
OF THIN GAUGE COIL STOCK

## SUTTON-MAUST *Double-Tilt* Roller Levelers

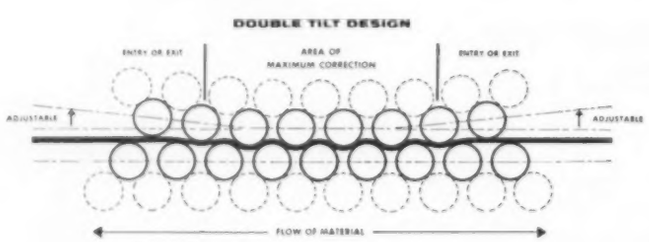



- Easy to adjust for contour correction.
- Mill shape correction, flattening and stress relieving in same pass.
- No pinch rolls, no entry marks. Reversible work flow without readjustment.

With new, patented CENTER ROLL GROUP DEFLECTION and exclusive DOUBLE-TILT DESIGN

Sutton-Maust double-tilt roller levelers provide the finest precision correcting and flattening of ferrous and non-ferrous sheets and strip. Accuracy obtained easily meets or betters the highest standards of quality.

In the exclusive double-tilt design, the top work rolls are arranged in a symmetrical pattern with the entry and exit roll group separately tiltable. The entry roll group subjects material to gradually increasing waves, the centrally located roll group produces a series of uniformly deep waves for maximum correcting efficiency and the exit group completes the flattening perfectly.




Double-tilt makes possible easier feeding without use of pinch rolls; it eliminates entry marks in cut-to-length lines, and permits reversing work flow without readjustment.

With center roll deflection, the center group of work rolls is deflected by easy-to-adjust back-up roll banks to correct mill shapes. Pressure can be applied to many different points across the width of the material to correct contours. The exit roll group, which is not deflected, flattens and stress relieves the corrected sheets or strip in the same pass.

Sutton-Maust double-tilt roller levelers may be used for both sheets and coils in process lines, continuous galvanizing lines, cut-to-length lines and for tension leveling of coil stock, down to very thin gauges, at high speeds to new high standards of flatness. Machine sizes are available for all modern metals in any required width and in gauges from .001″ to .750″.

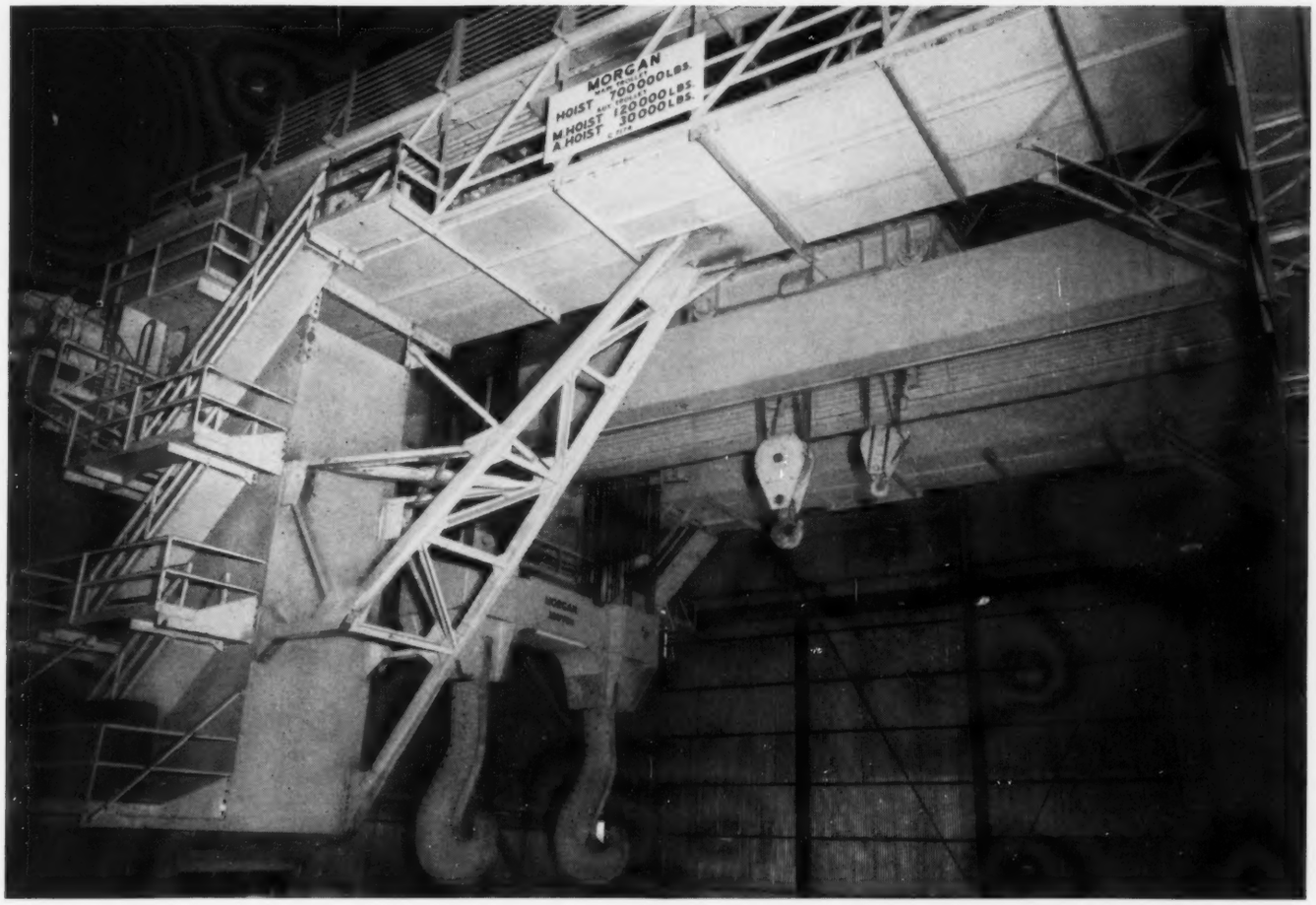
*Submit your leveling problems to us*

**Sutton-Maust Roller Levelers are manufactured by Maust Machinery Corporation, Queens Village 27, N.Y.**

**SUTTON** *Engineering Company*

FIRST NATIONAL BANK BLDG. • PITTSBURGH 22, PA.
PHONE: GRANT 1-8077 PLANT: BELLEFONTE, PA.

Manufacturers of Straighteners • Hydraulic Extrusion Presses • Centerless Bar Turners • Rotary Swagers • Sheet Levelers • and other Processing Machines for Modern Metals

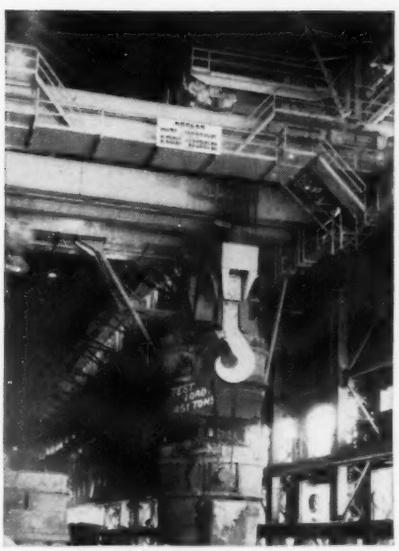



*At Granite City Steel...*

## MORGAN CRANES MOVE THE HEAVY LOADS

This 350/60/15 ton, 67′ span, ladle crane at Granite City, Illinois, demonstrates the extra quality steel companies expect—and get from Morgan. The photo at right shows the same crane undergoing a load test—carrying 451 tons—immediately after installation.

Efficiency and reliability in either mill modernization or expansion result when you have a Morgan Engineering man on your planning team. Call him to get facts on Morgan cranes and other Morgan mill equipment that will help speed production and lower your costs.



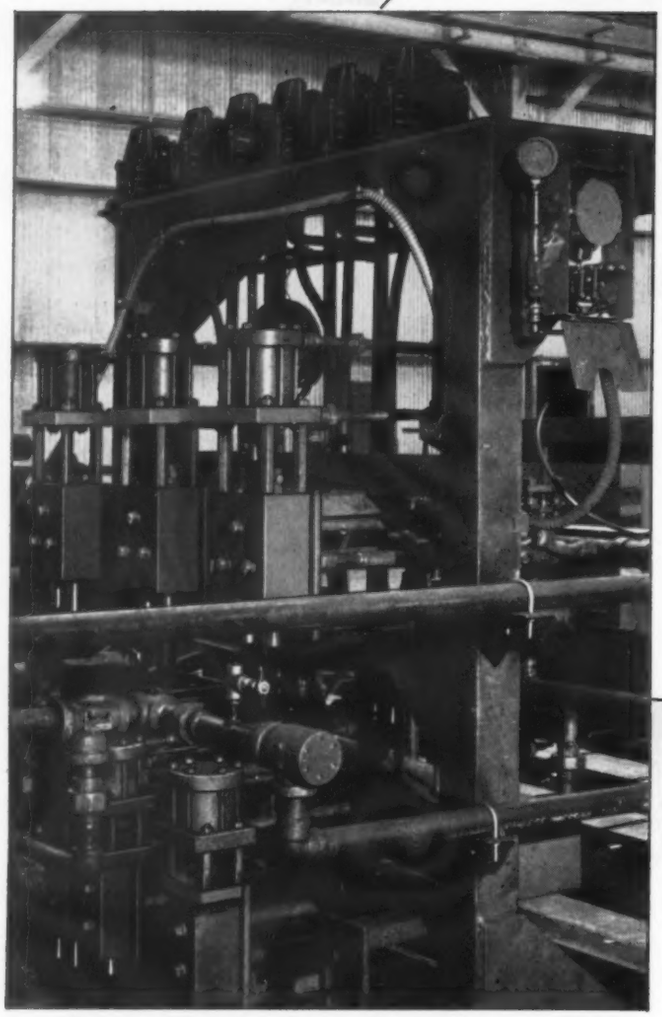
THE
**MORGAN**
ENGINEERING CO. *Alliance, Ohio*

**Overhead electric traveling cranes, gantry cranes, open hearth special cranes, blooming mills, structural mills, shears, saws, auxiliary equipment and welded fabrications.**

# HUNT VALVES

## provide around-the-clock dependability

## at Granite City Steel



This valve stand in the cold strip mill is one of several key Hunt valve applications at Granite City Steel.

With Hunt valves located at many points throughout the hot and cold mills, Granite City Steel produces high quality steel, turn after turn.

Descaling, cold strip alignment, oil spraying of sheets in process . . . these are typical of the operations being controlled by Hunt hydraulic and air valves. An example is hot strip descaling where Hunt 4 in. descaling valves control 1200 psi water on a mill averaging 300 passes per hour. These valves have provided continuous, dependable service for 23 years, with minimum maintenance.

The Hunt line includes valves ranging from 1/8 through 8 in. sizes, for vacuum to 300 psi air, and for water, water soluble oil or oil to 5000 psi.

Leading steel producers consistently choose Hunt valves. Your nearby Hunt representative can tell you why. Call him today.

For more information, write for Bulletin 603. Address Hunt Valve Company, Salem, Ohio, Dept. ISE-461.

**HUNT**

**QUICK-AS-WINK® AIR AND HYDRAULIC**

**VALVES**

HUNT VALVE COMPANY • DIVISION OF IBEC • SALEM, OHIO

3008

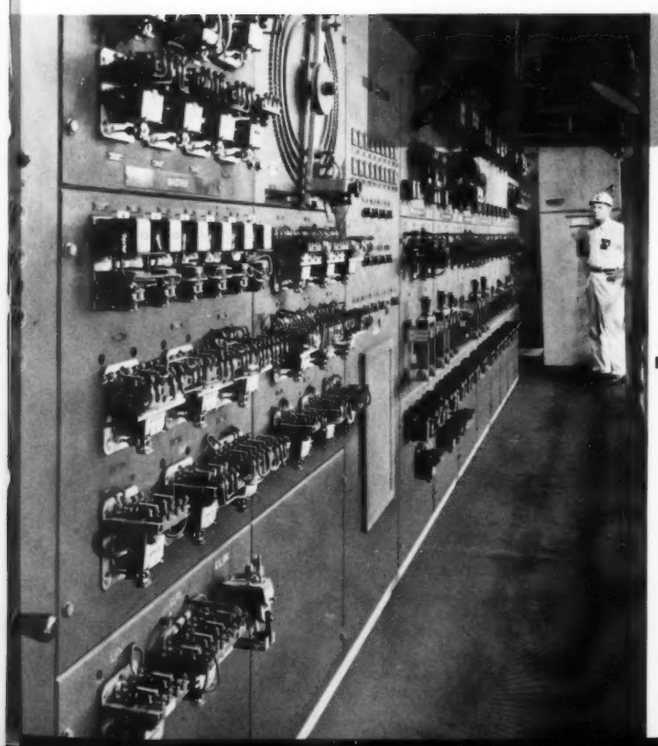
# PICK A PROCESS... ANY PROCESS... AND DISCOVER THE DYNAMIC ALLIS-CHALMERS LEADERSHIP IN POWER FOR STEEL

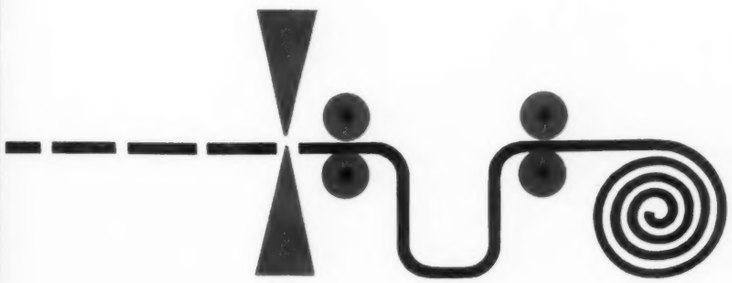
## Allis-Chalmers electrical equipment serves practically every process at Granite City Steel Company

Take a tour through the mill at Granite City Steel Company — and everywhere you look, you'll see Allis-Chalmers motors, m-g sets, controls, substations, power transformers, switchgear and other major electrical equipment.

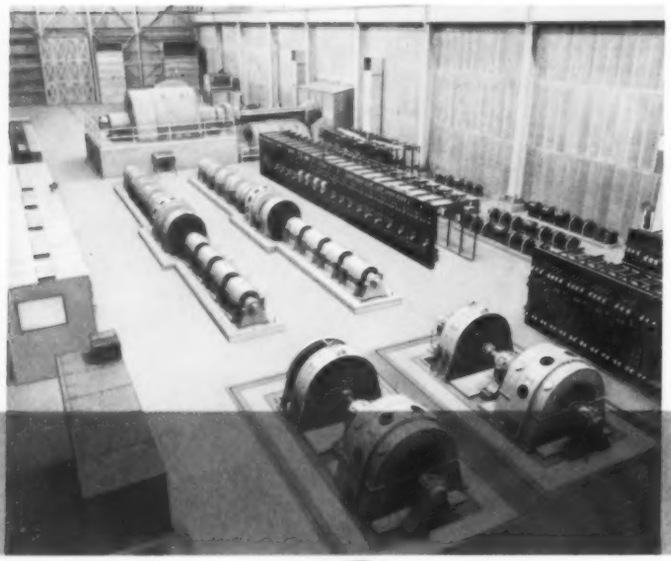
Allis-Chalmers can also help you serve tomorrow's markets *profitably* . . . from blooming mill to shearing line, and beyond. See your A-C representative, or write directly to Allis-Chalmers, Milwaukee 1, Wisconsin.

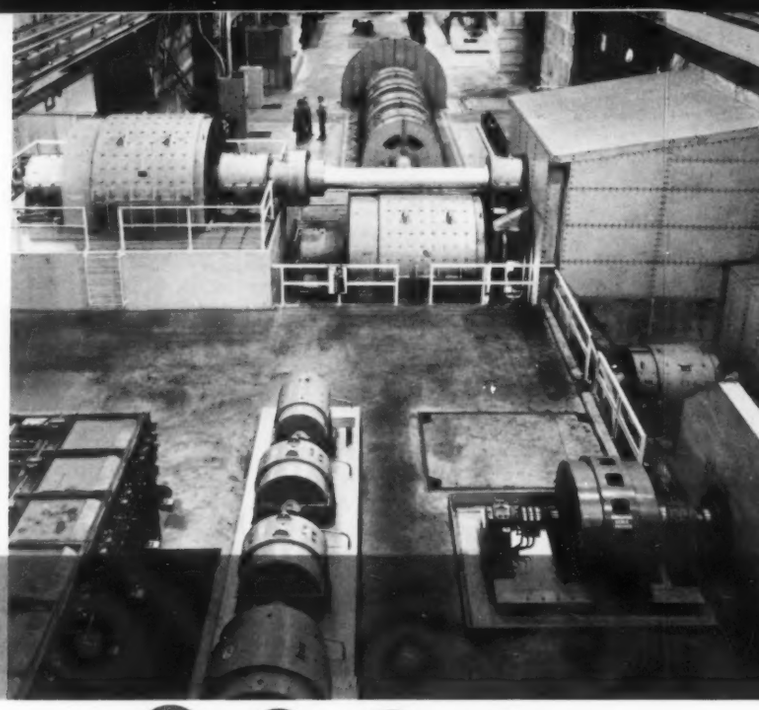
**BLOOMING MIL**
45-in. by 115-in. r
slabbing mill. A
serving this mill
switchgear, consta
sets, and *Regulex*

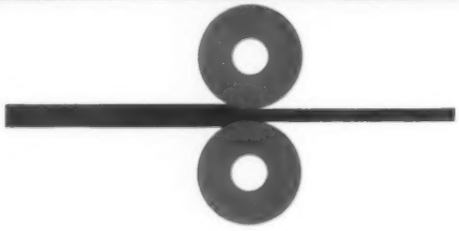




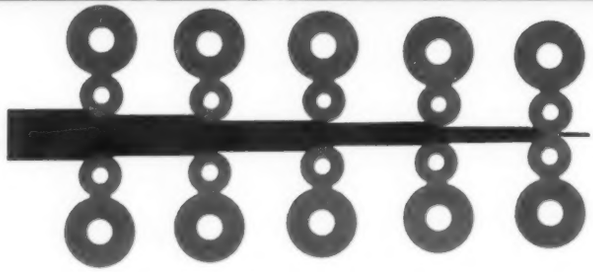
**SHEARING LINE** — Allis-Chalmers dc adjustable-voltage control and dc drives provide accurate shearing and careful handling (magnetic piler) of sheets at speeds up to 1000 feet per minute.



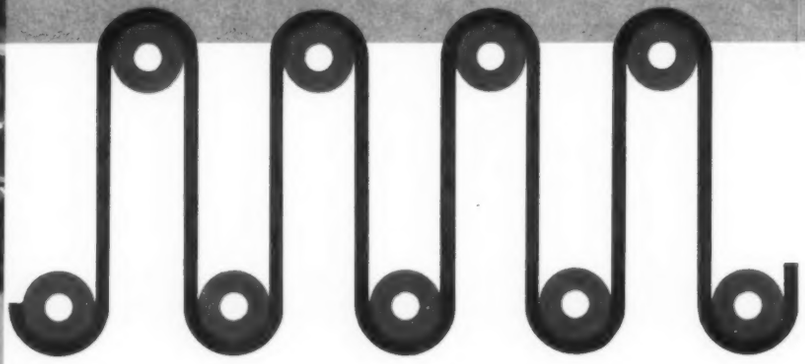




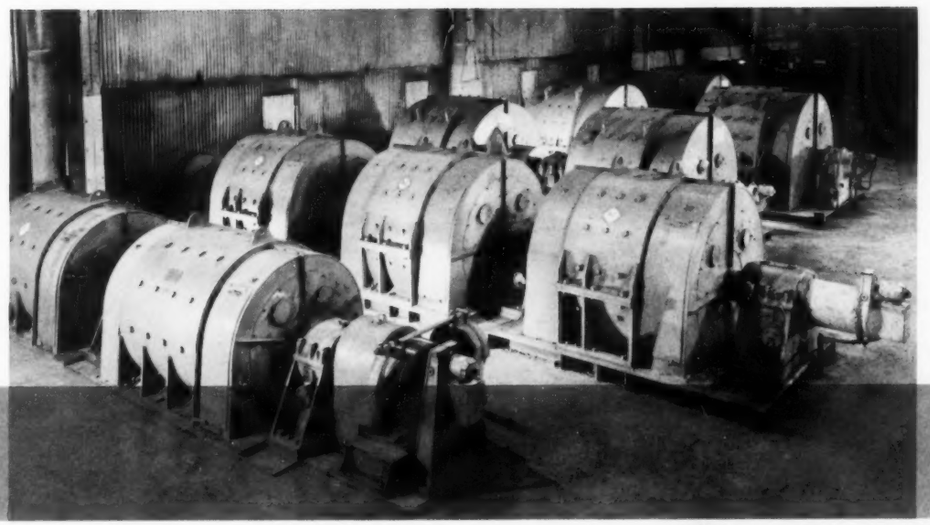
**BLOOMING MILL** — Installed in 1953, this 45-in. by 115-in. mill operates as a high lift slabbing mill. Allis-Chalmers equipment serving this mill includes dc control and switchgear, constant and variable voltage m-g sets, and *Regulex* exciter sets.



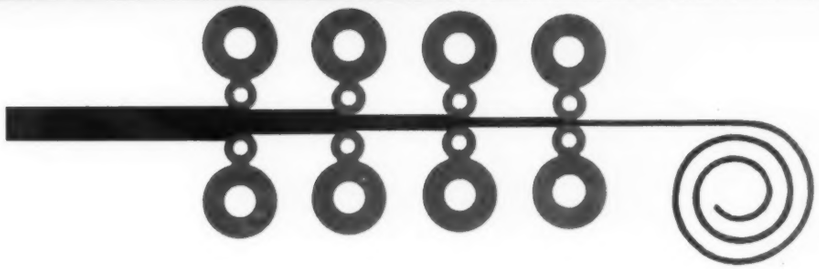
**HOT STRIP MILL** — Granite City's hot strip mill has grown from a three-high rougher with a four-stand finishing train, installed in 1936, to a four-high reversing rougher with five-stand finishing train, completed in 1952. This mill is now being further upgraded with the addition of an Allis-Chalmers feedback automatic gage control. Other A-C equipment: an 8000-kw m-g set and various controls.



**CONTINUOUS TINNING LINE** — When this electrolytic tinning line went into operation in 1960, sixty-eight 5-hp Allis-Chalmers TEFC dc gearmotors powered the plating rolls. Additional Allis-Chalmers motors and supporting m-g sets provide power throughout the line.



**CONTINUOUS ANNEALING LI**
annealing line, with its sophistica
of strip per month in thickness
1200 to 1350 F. A total of 101 All
line, supported by four variable-
motors, in addition, drive auxilia



rown from a
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**COLD REDUCTION MILL** — In 1958, Granite City's four-stand cold strip mill was increased from 9600 hp at 2800 fpm to 18,700 hp at 3600 fpm. Downtime for the change-over was three weeks. This power-speed increase provides a 35 percent increase in sheet-gage tonnages. Allis-Chalmers electrical equipment on this line includes motors, supporting m-g sets, and 400-cycle control.

**SENDZI**
mill, now
stand co
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reduced
thin tinp
ness. Ma
4000 hp
reel. Thi
Chalmers
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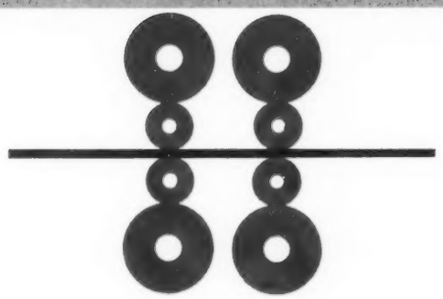

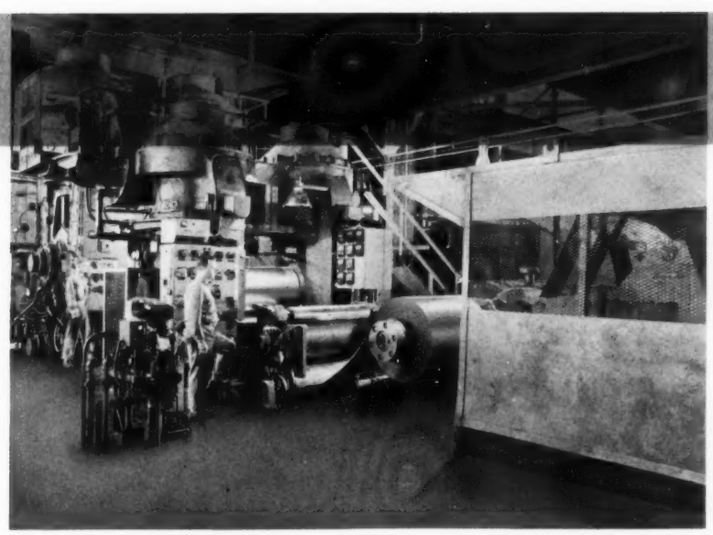

**TWO-STAND TEMPER PASS MILL** — Granite City's two-stand temper pass mill produces cold-rolled strip in both the standard and thin tinplate gages suitable for use in can production. An Allis-Chalmers four-machine, 1165-kw m-g set supports the 500-hp main roll drive motor, 300-hp upper and 150-hp lower delivery tension motors, and 150-hp delivery reel motor. A *Regulex* exciter set and controls are also used.

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**CONTINUOUS ANNEALING LINE** — This high-speed continuous annealing line, with its sophisticated control, can process 20,000 tons of strip per month in thicknesses ranging from .003 to .024 in. at 1200 to 1350 F. A total of 101 Allis-Chalmers motors operate on this line, supported by four variable-voltage m-g sets. Seventy-one A-C motors, in addition, drive auxiliary equipment.

**SENDZIMIR MILL** — A new 40-in. Sendzimir mill, now being installed, will allow the four-stand cold strip mill to operate more efficiently. Coils of steel that have been partially reduced on the cold strip mill are further reduced on the Sendzimir mill to the very thin tinplate gages . . . down to .004-in. thickness. Maximum speed will be 3500 fpm with 4000 hp on the stand and 1200 hp on each reel. This mill will be equipped with Allis-Chalmers feedback automatic gage control. Main drives will consist of four 600-hp and two 2000-hp motors, with a five-machine, 5200-kw m-g set. Magnetic amplifiers operate directly into the main drive motor fields, eliminating pilot exciters.

**SHEET TEMPER MILL** — This mill, which can operate at 3000 feet per minute, was extensively modernized by Allis-Chalmers several years ago. Controls, switchgear, magnetic amplifiers, and two 225-kw drag generators were installed. This equipment operates in conjunction with motors and supporting m-g sets furnished in 1936.

*Take a tour through*

GRANITE CITY
STEEL COMPANY

ALLIS-CHALMERS

# POWER FOR STEEL

**Motor thrives**
tube-type sync
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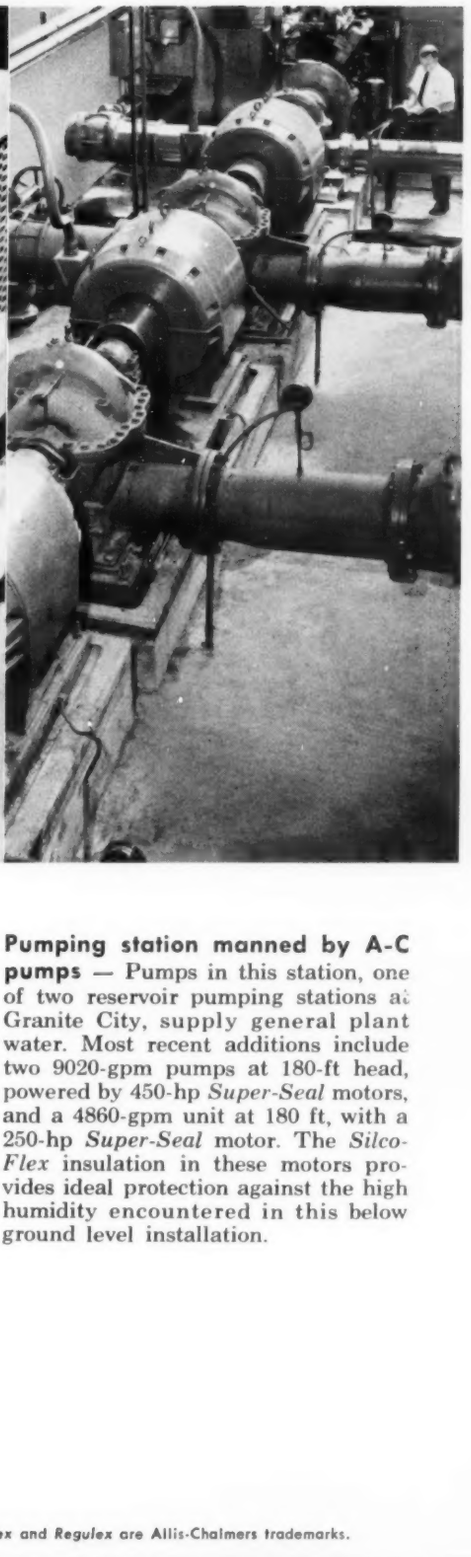
A-1453

# MODERN, DEPENDABLE EQUIPM



**Controls in balcony dir downstairs "show"** — T line-up of Allis-Chalmers fr access high voltage motor trollers, installed in the gra level balcony of the reserv pumping station, provides a venient, compact control cen

**Starting line for mill powe** This 6900-volt metal-clad swit gear serves the Granite C slabbing mill. This is but one many power centers supplied Allis-Chalmers.

**es on outdoor life**—This ynchronous motor, rated ower, drives the forced- pplying air to traveling sintering furnace at Gran- s-Chalmers complete line ors in any integral horse- or operation in practically nent.

**Daily menu: "roast motor with dust garnish"** — A *Super-Seal* open motor in the sintering plant at Granite City, mounted atop the firing hood, drives the swinging spout feeder. Though it's bathed in ovenlike heat and showered with abrasive dust, this motor keeps on performing day after day. Its formula: remarkable *Poxeal* insulation — an Allis-Chalmers development that enables open motors to shrug off heat, moisture, dust, oil, and most acids, alkalies and other contaminants.

**Pumping station manned by A-C pumps** — Pumps in this station, one of two reservoir pumping stations at Granite City, supply general plant water. Most recent additions include two 9020-gpm pumps at 180-ft head, powered by 450-hp *Super-Seal* motors, and a 4860-gpm unit at 180 ft, with a 250-hp *Super-Seal* motor. The *Silco-Flex* insulation in these motors provides ideal protection against the high humidity encountered in this below ground level installation.

**"Front door" for sinteri plant power** — This 1000- distribution substation serves Granite City sintering plant. T transformer in the center redu voltage from 2400 to 480 vo Low-voltage switchgear is loca to the right. Also located in room are two 15-hp and ei 5-hp Allis-Chalmers packa drives for variable speed con of the sintering machine, sin cooler and table feeders.

*Super-Seal, Poxeal, Silco-Flex and Regulex are Allis-Chalmers trademarks.*

# MODERN, DEPENDABLE

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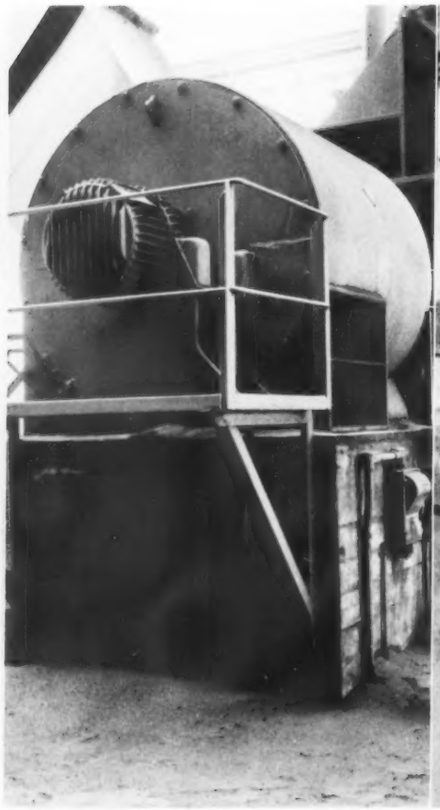

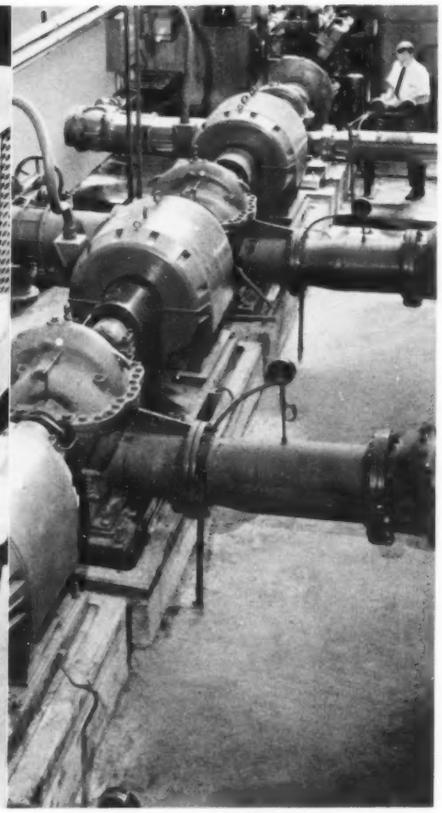

**Motor thrives on outdoor life**—This tube-type synchronous motor, rated 2000 horsepower, drives the forced-draft fan supplying air to traveling grates in the sintering furnace at Granite City. Allis-Chalmers complete line includes motors in any integral horsepower size, for operation in practically any environment.

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A-1453

*Super-Seal, Poxeal, Silco-Flex and Regulex are Allis-Chalmers trademarks.*

# LE EQUIPMENT for greater effici

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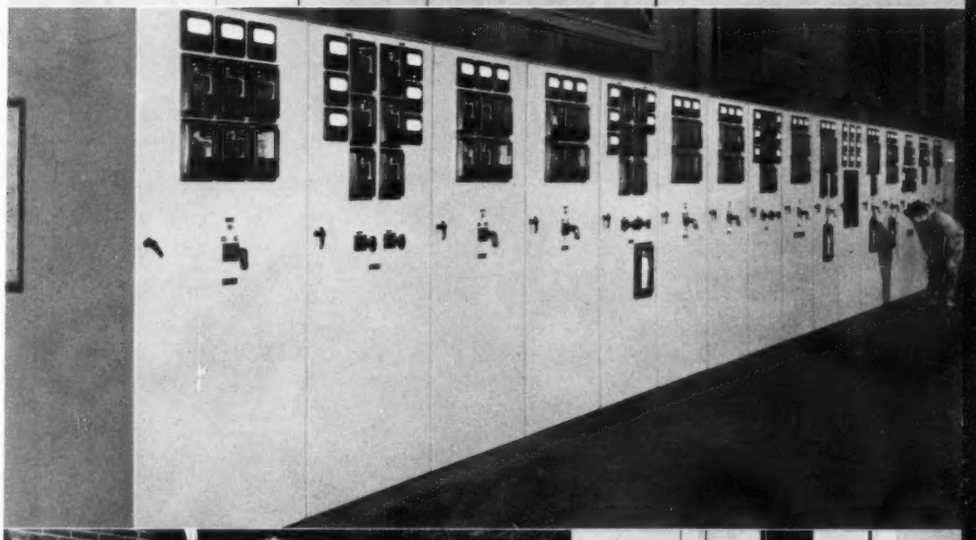
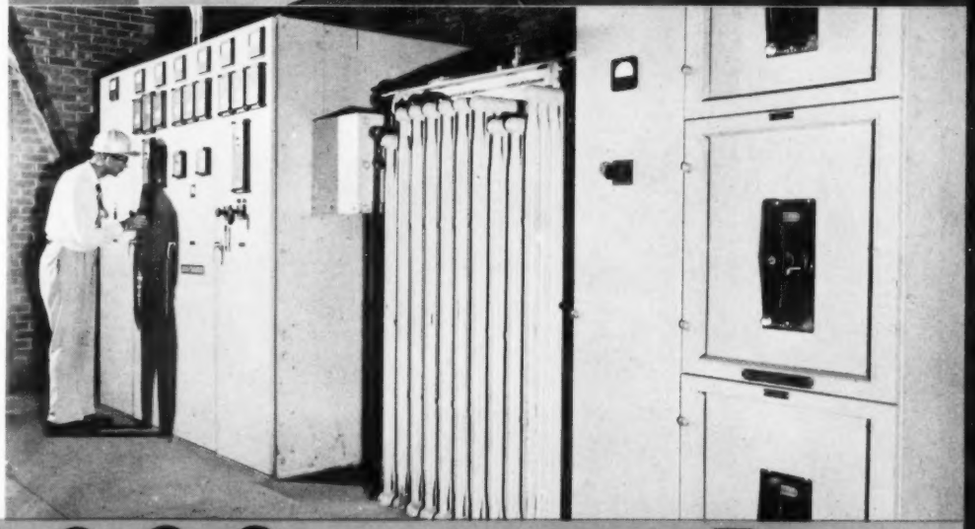
**Controls in balcony direct downstairs "show"** — This line-up of Allis-Chalmers front-access high voltage motor controllers, installed in the grade-level balcony of the reservoir pumping station, provides a convenient, compact control center.

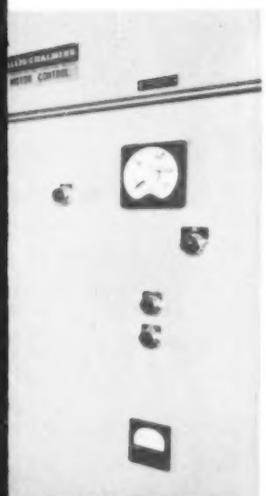


**Starting line for mill power** — This 6900-volt metal-clad switchgear serves the Granite City slabbing mill. This is but one of many power centers supplied by Allis-Chalmers.

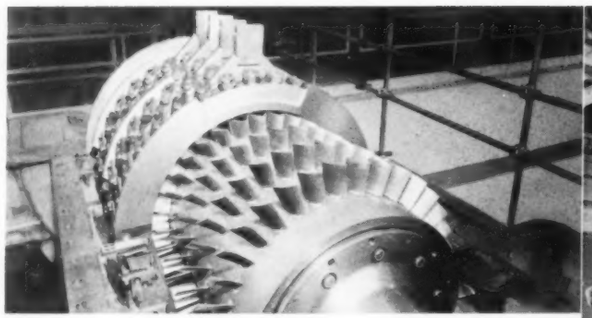


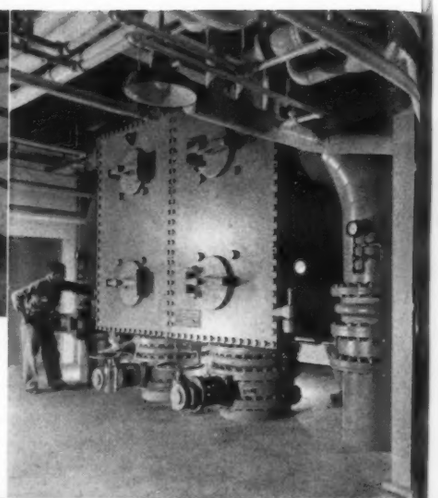
**"Front door" for sintering plant power** — This 1000-kva distribution substation serves the Granite City sintering plant. The transformer in the center reduces voltage from 2400 to 480 volts. Low-voltage switchgear is located to the right. Also located in this room are two 15-hp and eight 5-hp Allis-Chalmers packaged drives for variable speed control of the sintering machine, sinter cooler and table feeders.

# r efficiency in every steel mill process



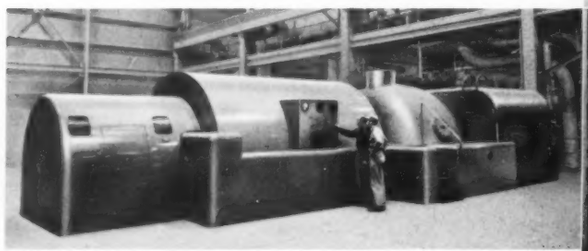
**Adjustable blade control extends compressor range** — To meet fluctuating large-volume air demands of blast furnaces and oxygen plants, fully adjustable stator blades extend the operating range of highly efficient axial compressors. Allis-Chalmers also furnishes a complete line of centrifugal and rotary compressors.





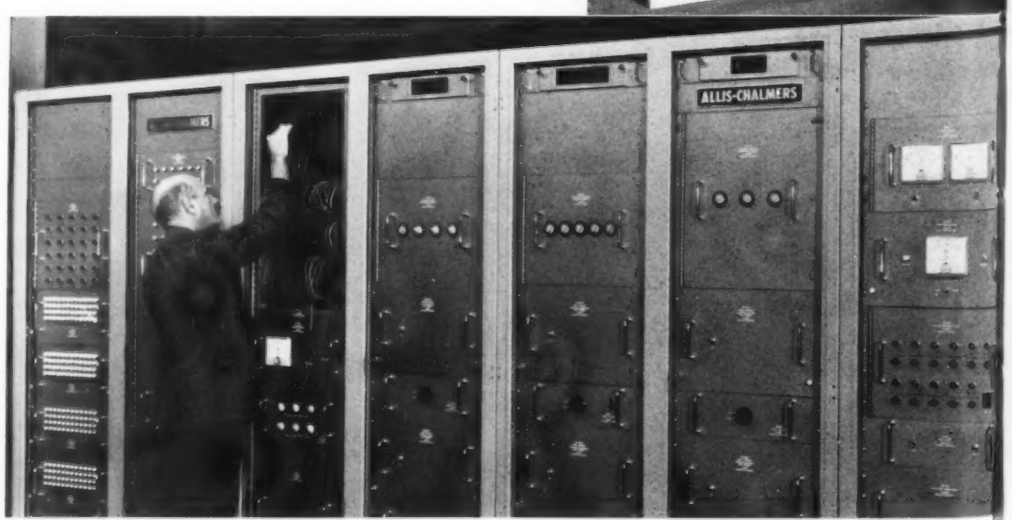
**Top performance, compact size**—Allis-Chalmers offers a complete line of steam condensers and auxiliary air removal and water pumping equipment. Features include rectangular condensers requiring minimum installation space and epoxy-coated water boxes to combat corrosion.

**Economical power for steel mills** — This 33,000-kw turbine-generator serves a large Eastern mill. Allis-Chalmers manufactures steam turbine-generator units, from 2000 kw up, designed specifically to meet the fluctuating load demands encountered in steel mill applications.



**Power supply rectifiers** — This 1500-kw silicon rectifier, one of three mill supply units furnished by Allis-Chalmers for an Eastern steel mill, provides the mill with 250-volt dc power from an ac source. The complete line of Allis-Chalmers rectifiers includes both silicon and mercury-arc units for steel mill service.

**For quality control, reduced processing costs** — *Systemation* engineers at Allis-Chalmers will undertake responsibility for design of complete operating facilities. *Systemation* is based on a thorough understanding of mill processes and their electrical requirements, gained from years as a major equipment supplier. Added is the experience of over 500 successful advanced electronic control systems by Consolidated Systems Corporation, an affiliate company. Shown is an electronic control system for automatic programming of a reversing rougher.




*Systemation* is an Allis-Chalmers servicemark.

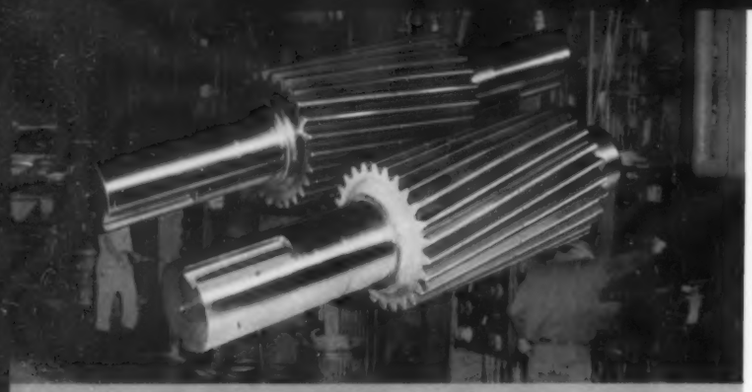
**ALLIS-CHALMERS** A-C *Milwaukee 1, Wisconsi*

## Greetings to Granite City Steel

*— a good neighbor and a good customer*

**Growth is our pattern, steel rolls our business** The mold sweep held by Deac Scholl, Manager of Roll Sales, will help form the contours of another steel roll—one of the hundreds furnished by National in its rapid growth as a steel roll supplier. Their high quality, proved in service day after day, is responsible for the increasing number of mills turning to National for their steel roll requirements. Our sixty years experience in roll making is your assurance of our dependability and know-how. Talk with a National man about your next roll requirement—whether steel, iron or nodular iron. You'll find out why . . . NATIONAL'S THE GROWING NAME IN ROLLS.

**NATIONAL ROLL & FOUNDRY DIVISION**
**GENERAL STEEL CASTINGS CORPORATION,** Avonmore, Pennsylvania
General Steel Castings Corporation, General Offices: Granite City, Ill. Plants: Granite City, Ill., Eddystone, Pa., Avonmore, Pa.
Subsidiary: St. Louis Car Company, St. Louis, Mo.



TSP mill pinions drive 56" four stand cold reduction mill.

# THREE REASONS WHY GRANITE CITY STEEL HAS SINCE 1918

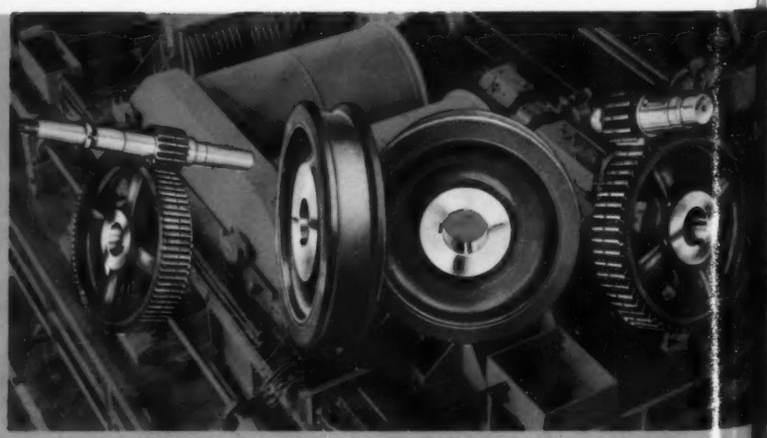
TSP edger screws on hot strip mill.

**1. THEY LAST LONGER** than any other product in the same service. TSP hardening results in a file hard surface to the full depth of permissible wear for maximum life. A core, refined for toughness and ductility, gives maximum strength.

**2. THEY SAVE MONEY** because of their phenomenally long wear qualities. TSP hardened products seldom need to be removed from your machine for maintenance or replacement. The countless thousands of dollars that have been saved by major steel companies in both maintenance and replacement is a basic reason for their wide usage.

**3. THEY ARE GUARANTEED** in an exclusive written guarantee to outwear any other competitive product in the same service. This unique guarantee that accompanies every TSP product could only be successfully made on a superior product. Of the thousands and thousands of TSP products sold, it has been seldom necessary for any company to call upon this guarantee.

TSP screwdown screws and nuts on 45" blooming and



TSP wheels and gearing on 325 ton ladle crane.

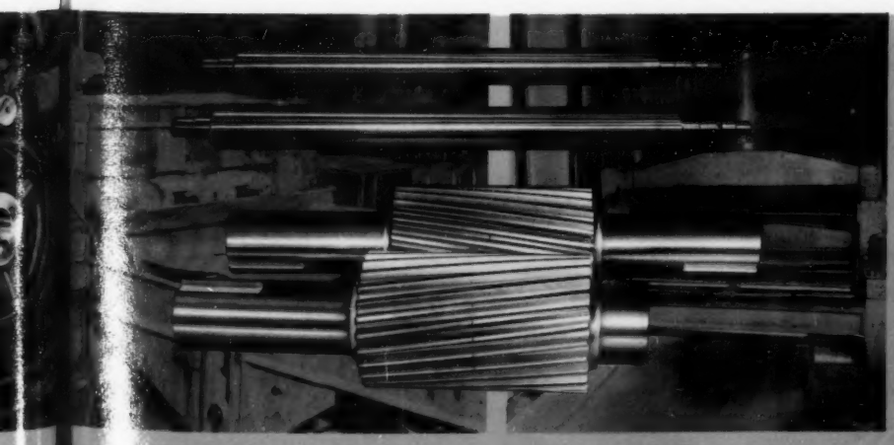
TSP track wheels and gears on coke pusher.

**TOOL STEEL PROCESS** products have been purchased by Granite City Steel Co., Granite City, Ill. since 1918. This continuous confidence in the quality of TSP products is a superb recommendation from one of the nation's great steel companies. TSP products are in use in every department. They include screwdown screws and nuts, gears and pinions, track and sheave wheels, leveller, pinch, back-up and coiler carrying rolls, arbors, shafts and axles, sprockets and mill pinions. Write for TSP Bulletin for the Steel Industry.

THE
**TOOL STEEL GEAR & PINION COMPANY**
**CINCINNATI / OHIO / USA**

MEMBER OF AGMA

**the standard of quality since 1909 for gears ■ pinions ■ rolls ■ wheels and other hardened products.**



TSP rolls and gears on processing and shearing line.

TSP sheave wheels on slab yard crane.

# BADALL ROLLS

## CUT REPLACEMENT COSTS AT GRANITE CITY STEEL

**BADALL HARDENED STEEL ROLLS** replaced 90 cast iron rolls on Granite City Steel's hot strip runout table in 1955. All Badall rolls are still in service. No replacement has been necessary due to roll breakage, warpage, high temperature deterioration, galling or oxide pick-up, normally experienced with cast iron rolls. Badall rolls have resulted in substantial savings in downtime and replacement costs.

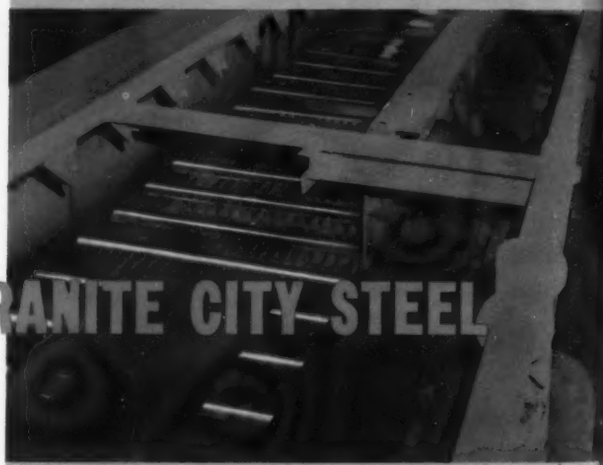
The 10" Badall rolls used are of carbonitrided steel, tubular design with 1½" wall thickness. A steel shaft runs through center. The comparatively low cost plus exceptional long-wear qualities make Badall rolls a wise investment. For technical data on heat treating and manufacturing of Badall rolls, write for Bulletin B-160.

**THE BADALL COMPANY, INC.**

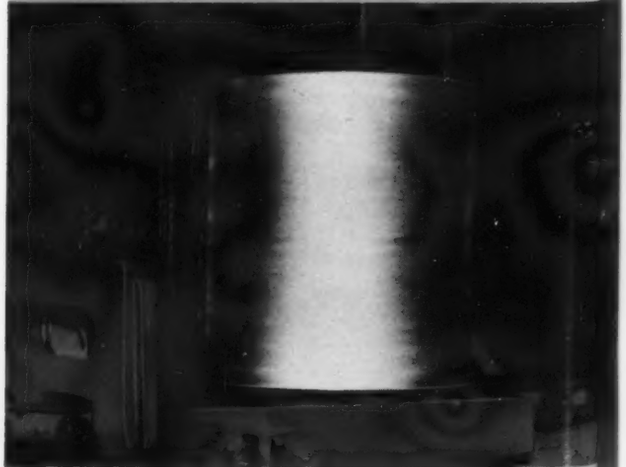
HAMMOND, INDIANA

A wholly owned subsidiary of The Tool Steel Gear and Pinion Co. / Cincinnati / Ohio / U.S.A.

**Hot strip mill, Granite City Steel Company. A hot strip over the Badall runout table rolls.**



**There are 159 rolls in this table. Only about half of the table is equipped with strip cooling water spray.**



**Thousands of coils of strip steel are turned out on Granite City's hot strip line equipped with Badall rolls.**

PORTRAIT OF PROGRESS: *Wean No. 2 Alkaline Tinning Line at Granite City Steel Company's Granite City Works*

# Granite City Increases its Range of Tin Plate Widths with New Wean Alkaline Line

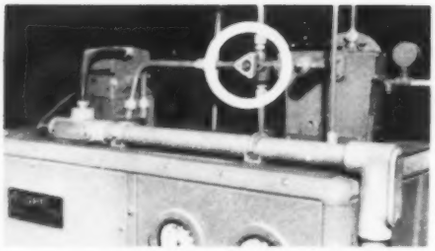
To supply the full range of coil widths required by the can manufacturing companies it serves, Granite City Steel Company recently installed this Wean alkaline-type tinning line.

Capable of handling coils up to 40,000 lbs. with an outside diameter of 72", this line is designed to process tin plate at speeds up to 1200 fpm. The line can accommodate strip from 18" to 38" in width and from .003" to .015" in thickness.

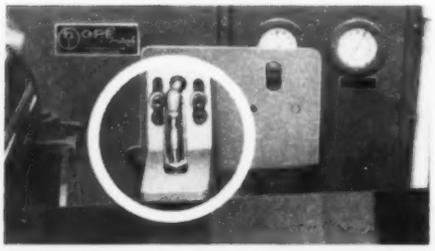
The new Wean line has been designed to economically produce differential plating, providing more versatility in meeting customer requirements. Strip storage is provided in looping towers at both the entry and exit sections of the line in order to maintain constant flow of material through the processing section.

During its three-decade partnership with the steel industry, Wean Engineering Company has designed more than 80% of all electrolytic tinning facilities in operation today. We invite you to put this experience to work on your next tinning line project.

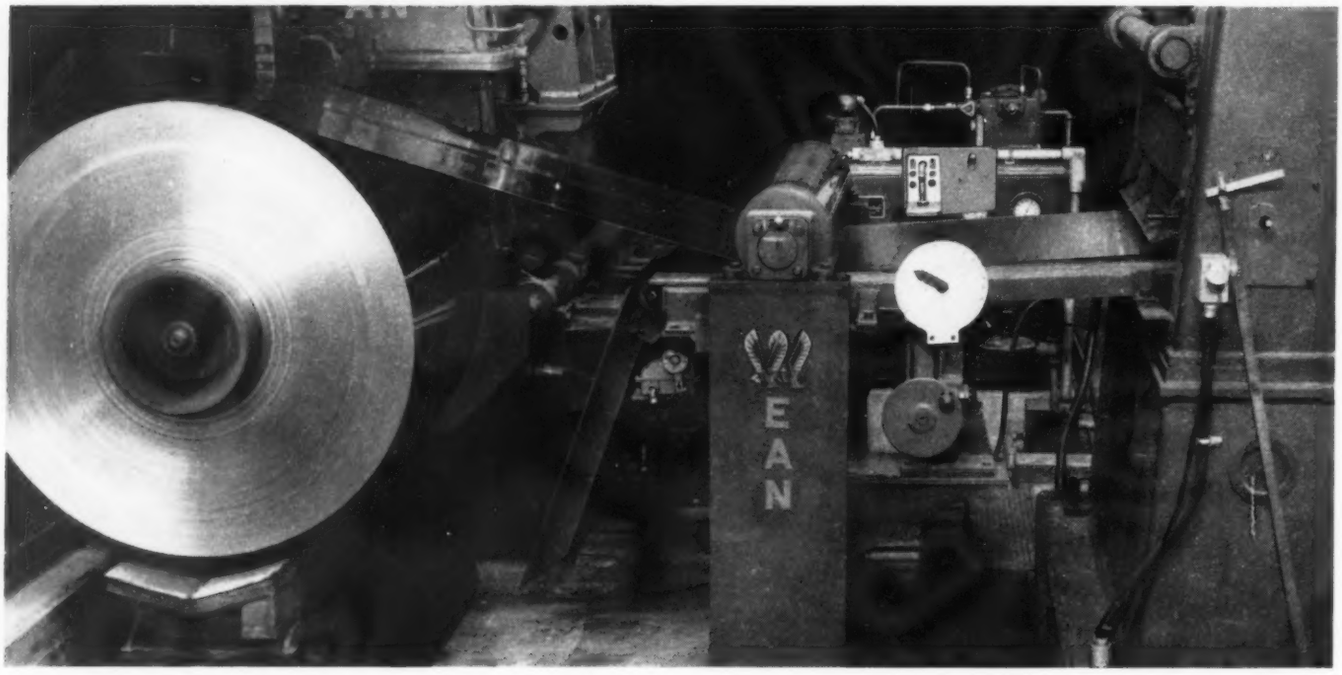
**THE WEAN ENGINEERING COMPANY, INC. · WARREN, OHIO**



**GPE CONTROLS ADJUSTABLE-GAIN BOOSTER** — Even a slight error in strip position produces maximum corrective force with complete stability. A simple screwdriver adjustment matches the control system to your strip processing line. If it doesn't have this advanced feature, it's just not a modern strip guide!



**NON-CONTACT, NON-CLOGGING SENSING HEAD** — Nothing touches the gleaming surface of the strip but a breath of air! And only GPE Controls gives you precise, simple pneumatic sensing with patented non-clogging design. Maintains accuracy of control without excessive maintenance.




# High-finish tinplate line at Granite City Steel uses GPE Controls Edge Guide for mirror-edge wind-up coil

This GPE Controls air-hydraulic strip guide – on the "B" Electrolytic Tin Line at Granite City Steel – is one of the four similar units now operating in this modern mill. And *three more* GPE Controls Strip Guiding Systems will soon be in operation.

Here at the wind-up, the line operates at about 1000 feet per minute. GPE Controls Strip Guide continuously positions the wind-up reel to produce a mirror-like metal edge on the wind-up coil. Tinplate quality is protected in handling and shipping because the coil edge is perfectly smooth!

Steelmakers and steel users alike have shown their preference for GPE Controls by making it the most widely used strip guide. For simplicity, for control accuracy, for construction that cuts maintenance to the bone—you can't beat GPE Controls!

*Write for informative Bulletin EG84*

**GPE Controls, Inc.**

240 East Ontario Street • Chicago 11, Illinois.

GPE Controls

A Subsidiary of GENERAL PRECISION, Inc.

SINCE 1878
GRANITE CITY STEEL®

## ...A GREAT NAME IN STEEL

# APEX and METALOK...

## GREAT NAMES IN STEEL INDUSTRY REFRACTORIES

## APEX

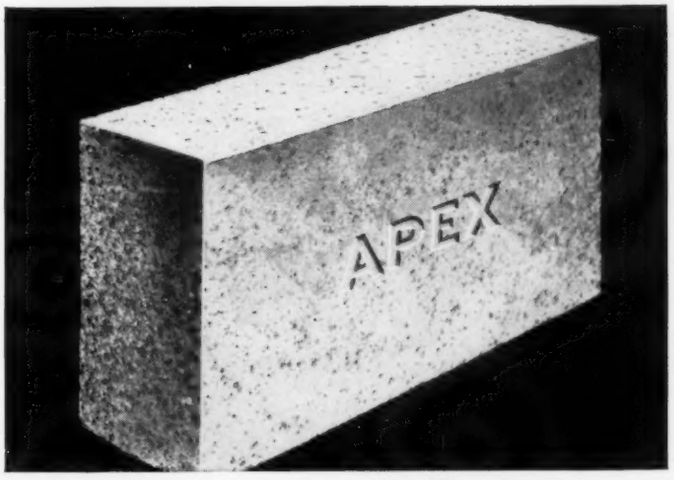
### SUPER DUTY FIRE BRICK

**WEIGH IN EXCESS of 150 lbs. per cu. ft.**

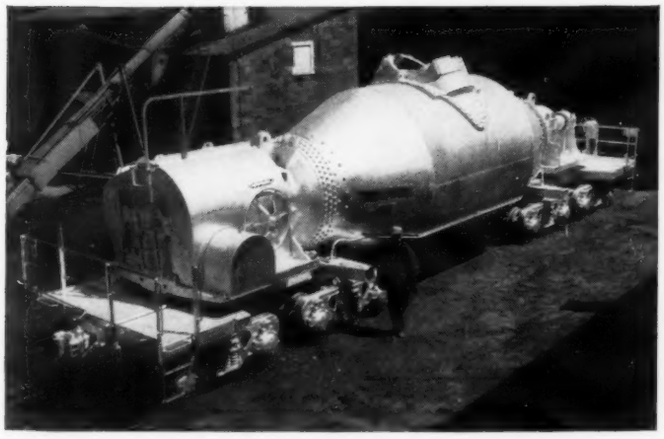
**APEX gives you more fire clay in its densest, most compact form to increase—**

- **Resistance to wear**
- **Heat storage and heat flow**
- **Hot load bearing strength**
- **Resistance to slag penetration**

**For record tonnage in closed hot metal torpedo type ladles, hot metal mixers and for maximum service and heat exchange in hot blast stove checkers and open hearth checkers.**




## METALOK MORTAR



Successfully resists heavily laden iron oxide slags. With its high refractory value, excellent workability for trowelling and its characteristic of remaining in suspension while in dipping consistency, METALOK meets every requirement as a versatile slag resisting, heatsetting mortar.

For laying up ladle brick in open hearth steel ladles, as a leveling base for ladle brick bottoms and sidewalls in open hearth ladles, as a wash coating and patching material for ladle brick, as a mortar for fire brick linings in torpedo type closed and semi-closed ladles, hot metal mixers and wherever the penetration of slags and molten iron and steel should be held to a minimum.

**For money-saving long life and dependability, specify Walsh Steel Industry Refractories. Wire, write, or phone for details.**

WALSH REFRACTORIES CORPORATION
America's Best Clays

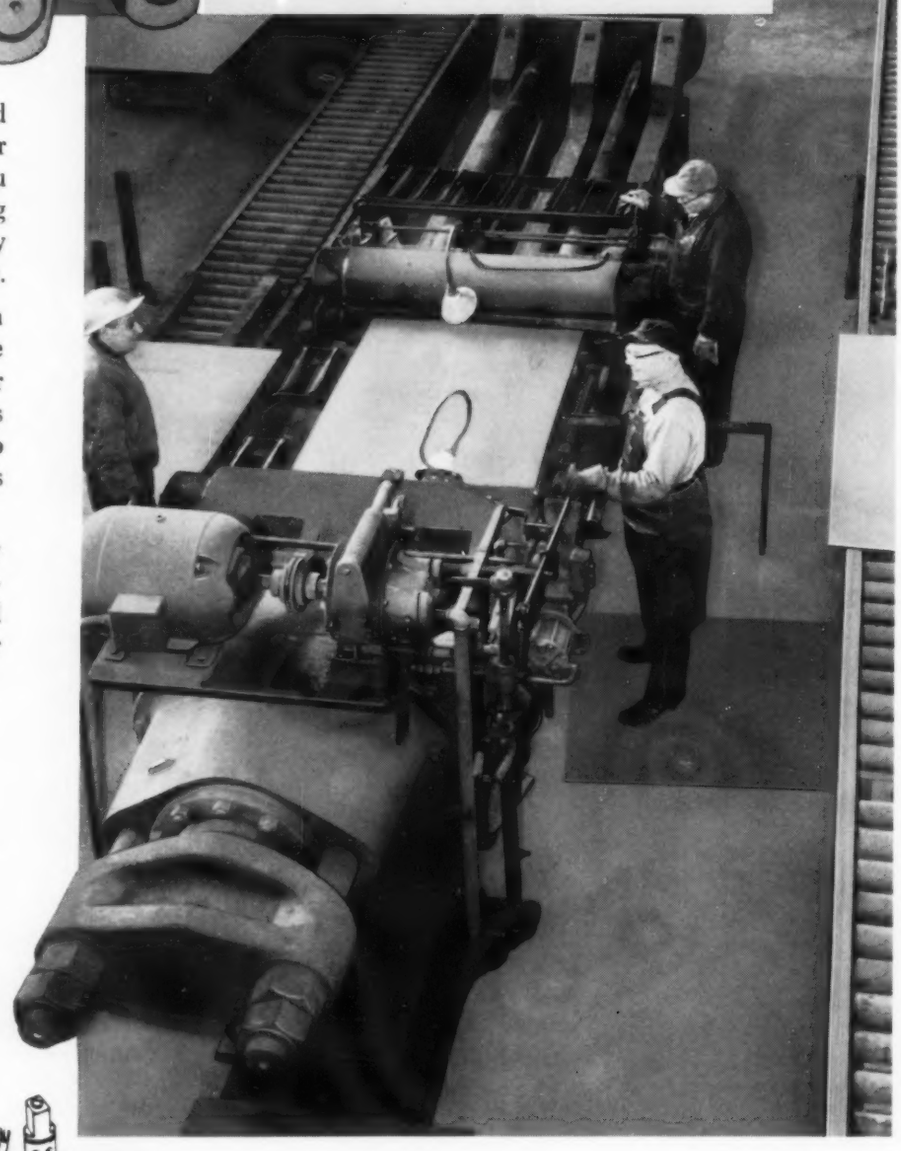
## WALSH REFRACTORIES CORPORATION

**101 FERRY STREET • ST. LOUIS 7, MISSOURI**

SPECIALISTS IN REFRACTORIES OF HIGH BULK DENSITY AND LOW POROSITY

# Designers and Builders of Rolls and Rolling Mill Equipment

## Hyde Park
### 250 TON
### STRETCHER LEVELLER
### at Granite City Steel



*Hyde Park* has been an honored name throughout the industry for more than sixty-five years. You will see it on Rolls and Rolling Mill Equipment wherever quality and high production are factors.

Now, with our expanded erection and engineering facilities, we are in a position to meet all your requirements in rolls, rolling mills and auxiliary equipment – also gray iron and alloy iron castings up to 80,000 lbs.

*Our Engineers* are always ready to co-operate with you in selecting and applying the rolls and equipment best suited to your operation.

**ROLLS**

- Nickel Alloy Grain Rolls
- Grain Rolls
- Chilled Rolls
- Nickel Chilled Rolls
- Moly Rolls
- Nodular Iron Rolls

All Grades Nickel Alloy Iron Rolls for Hot and Cold Rolling

**ROLLING MILL EQUIPMENT**

- Bar Mills
- Merchant Mills
- Roller Tables
- Stretcher Levellers
- Sheet Mill Shears
- Special Machinery
- Sheet and Strip Mills
- Pinion Stands
- Reduction Drives
- Roll Lathes
- Machine Work

**CASTINGS**

- Furnace Castings
- Heavy Die Castings
- Bases
- Housings
- Machinery Castings
- Slag Pots
- Heavy Tool Castings
- Floor Plates

*Our Foundry and Machine Shop facilities are equal to any of your requirements.*

## Hyde Park
## FOUNDRY and MACHINE CO.

HYDE PARK, WESTMORELAND COUNTY, PITTSBURGH DISTRICT, PA.

***GRANITE CITY, TOO, GOES***

# Single Stack-

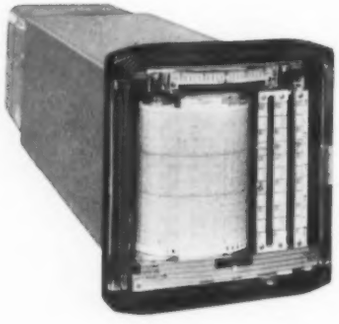
Granite City Steel, after checking the results of four Lee Wilson single stack furnaces and 12 bases, purchased 14 additional single stack high convection furnaces and 42 bases. Charge size is 72″ x 156″. This installation is a part of a total of 700 Lee Wilson high convection single stack furnaces that are used throughout the steel industry, wherever flat rolled products are made. *The Lee Wilson Engineering Co., Inc., 20005 Lake Road, Cleveland 16, Ohio.*

*Lee Wilson*

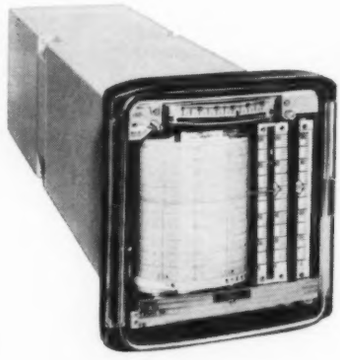
ORIGINATORS AND LEADING PRODUCERS OF

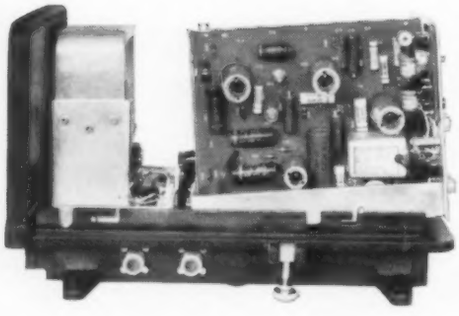
# TODAY *Taylor* MEANS CONTROL

**Whether you prefer miniature pneumatic, miniature electronic or large-case instruments**

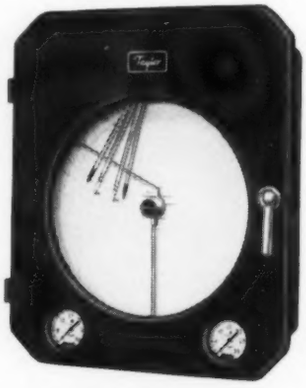


**TRANSCOPE* Recorders** (90J pneumatic, left; 700J electronic, right) are most convenient, most compact instruments yet developed for modern instrument panels. Powerful Servomatic motors give unprecedented recording accuracy, (½ of 1% standard; ¼ of 1% optional), also permit use of auxiliary functions such as integral alarms, retransmitting potentiometers, function generation and digital encoding . . . eliminating the need for external "black boxes." Front-of-panel control settings permit easy adjustment while recording. Ask for **Bulletin 98286** (pneumatic) or **98335** (electronic).





**700T Potentiometer Transmitter** converts a DC millivolt primary electrical signal into a 3-15 psi pneumatic output to controllers and receivers. Continuous, electronic standardization eliminates slide wires, batteries and moving parts. Plug-in service "cans" permit instant conversion from one type of service to another. **Bulletin 98262.**



**FULSCOPE* Recording Temperature or Pressure Controller** has been the favorite throughout industry for more than 23 years. Famous for dependable performance, accuracy and adaptability to changing process requirements. The double-duty model shown is ideal for two related variables. Ask for **Bulletin 98291.**

*Reg. U.S. Pat. Off.

*Call your Taylor Field Engineer or write for Bulletins.*
*Taylor Instrument Companies, Rochester, N. Y., and Toronto, Ontario.*

*Taylor Instruments* **MEAN ACCURACY FIRST**

# Chemico P-A Venturi Gas Washer Chosen By Granite City For New Blast Furnace

The venturi washer at the Granite City plant is just one of fifty CHEMICO venturi washers specified and installed by major steel producers for cleaning blast furnace gas. Performance figures and maintenance records of blast furnaces using CHEMICO venturi washers indicate the following:

1 The CHEMICO venturi washer is the most efficient wet washer in operation anywhere. Where higher top pressures are available, for example, gas can be cleaned to less than 0.003 Gr/Scf, eliminating the need for secondary precipitators.

2 CHEMICO venturi washers require virtually no maintenance for an entire furnace campaign.

3 Capital and installation costs are less than other primary or secondary gas cleaners.

4 Minimum space is required. Generally, the CHEMICO venturi washer is set into space formerly occupied by gas mains.

5 Water requirements are about a third of other wet washers.

6 Latest designs incorporate adiustable controls which enable maximum gas cleaning efficiency to be maintained regardless of wind rate.

If you are considering the installation of gas cleaning equipment on a blast furnace, a CHEMICO representative would be pleased to show you the kind of top-performance job you can expect from a Venturi washer. CHEMICO handles the complete job, **Planning, Design, Engineering, Erection and Start-up.**

CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
GAS SCRUBBER DIVISION
**320 Park Avenue, New York 22, New York**

*Sales Representatives in:*
Ferndale, Mich. • Chicago, Ill. • Los Angeles, Calif. • Houston, Tex. • Bartow, Fla. • Birmingham, Ala. • Millersville, Pa.

This 2500-ton-per-day sintering plant was a key project in the construction program of Granite City Steel Company.

## SINTERING PLANT AT GRANITE CITY STEEL COMPANY

# Designed and Built by McKee

The Granite City Steel Company sintering plant illustrated above is one of a long and steadily-growing line of modern ore beneficiation facilities designed and constructed by Arthur G. McKee & Company.

McKee leadership in engineering sintering and pelletizing plants, and other ore preparation facilities, is the result of many years of specialized activities in this field. In more than a half-century of intensive, world-wide engineering and construction for the steel industry, McKee engineers have accumulated an unmatched fund of knowledge and practical experience that can be invaluable to your company on any steel plant project from mine to finished steel.

**McKEE** ENGINEERING AND CONSTRUCTION SERVICES

M WKE

**THE McKEE ORGANIZATION**

**ARTHUR G. McKEE & COMPANY** 2300 Chester Avenue, Cleveland 1, Ohio. *Offices:* New York; Union, N. J.; Washington, D. C.; Houston, Texas. *Subsidiaries:* Toronto and Montreal, Canada; Mexico City, Mexico; Sao Paulo, Brazil; Buenos Aires, Argentina; London.

**WESTERN KNAPP ENGINEERING CO.** 650 Fifth St., San Francisco 7, Calif. *Western Knapp Offices:* New York; Chicago, Ill.; Hibbing, Minnesota.

Packaging tin plate coils using a PN tensioner and an RCN sealer

# Signode is proud to be serving Granite City Steel

The strength of steel applied at low cost by dependable tools helps make Granite City Steel's products cost less per ton. It enables them to insure better delivery to their customers. Signode steel packaging specialists have spent many weeks in this plant, cooperating with Granite City Steel people in developing methods and improving applications. This is a continuing service.

*First in steel strapping*

**SIGNODE**
**STEEL STRAPPING CO.**
**2644 North Western Avenue • Chicago 47, Illinois**

Offices Coast to Coast. Foreign Subsidiaries and Distributors World-Wide
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Electrolytic Tin Plate Line at Granite City Steel Co., Granite City, Ill.

# 56 Drives...56 Couplings...56 Places Where Maintenance Is Licked!

**DODGE PARA-FLEX FLEXIBLE CUSHION COUPLINGS**

In one steel mill operation after another, Dodge Para-flex is helping to improve the flow of production. Here 56 Para-flex Couplings contribute to a 12,000-ton-per-month capacity *without the necessity of lubrication or periodic inspection.*

During the 4 years that these amazing couplings have been used in American industry, replacements of flexing elements have been negligible. But if a change should be required, replacement is easy. On this tin plate line, for instance, the element can be replaced without removing either the reducer or the roll.

Incidentally, the hazard of arcing between motor reducers and rolls is eliminated. There is no metal to metal contact. The flexing element insulates against the flow of electrical current.

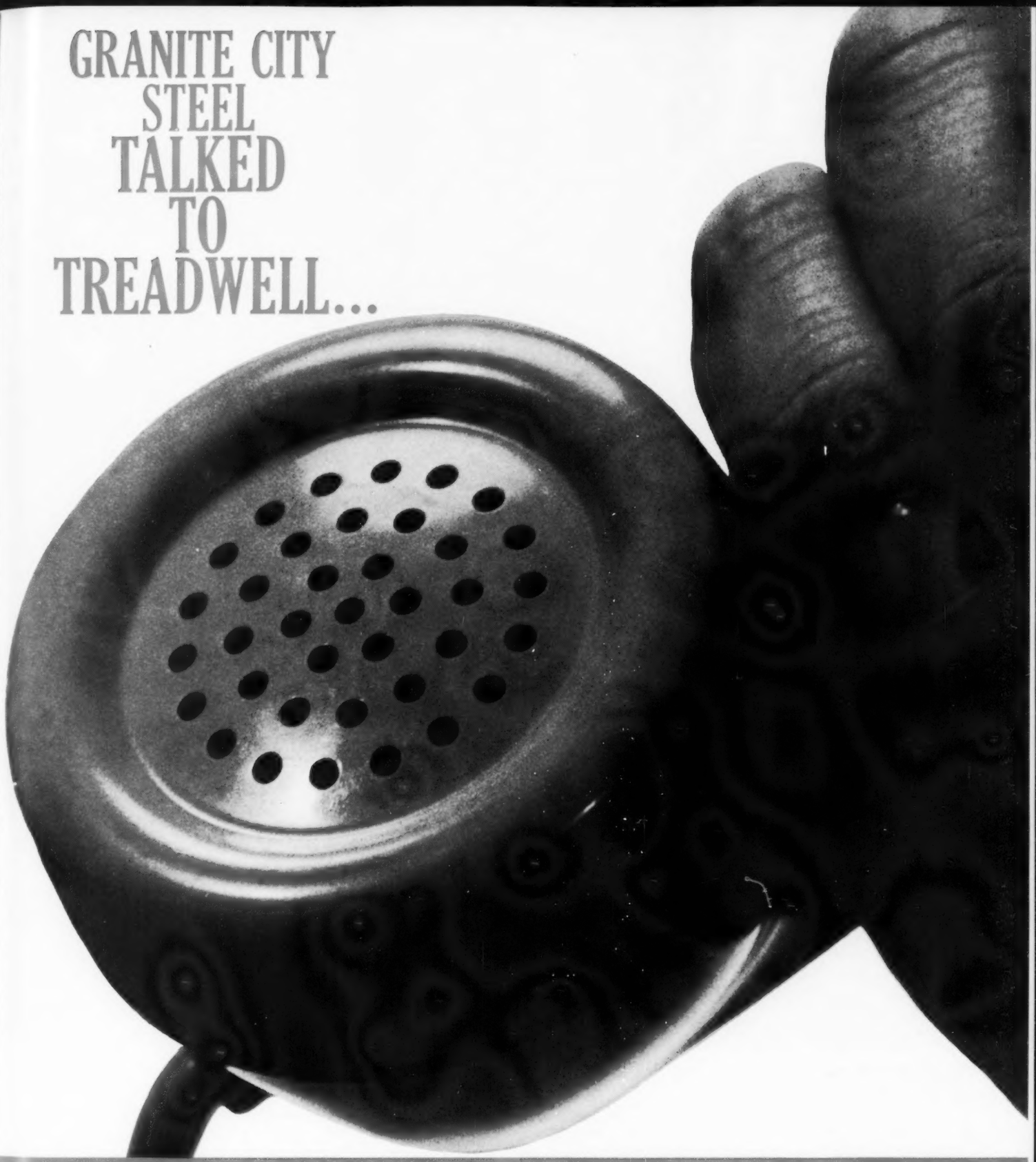
Para-flex Couplings take angular misalignment, parallel misalignment, end float or any combination of all three. They absorb vibration, cushion shock loads. Taper-Lock bushings provide "easy on — easy off" mounting. Standard types (illustrated) are made in capacities up to 3640 hp at 910 rpm. High Speed and Flywheel types are available for speeds up to 5230 rpm, and for high torque at all speeds. Ask your Dodge Distributor, or write us for complete technical bulletin.

Dodge Manufacturing Corporation, 5900 Union Street, Mishawaka, Indiana

*The Products with the Pluses...* **DODGE** *of Mishawaka, Ind.*

**CALL THE TRANSMISSIONEER,** your local Dodge Distributor. Factory trained by Dodge he can give you valuable assistance on new cost-saving methods.

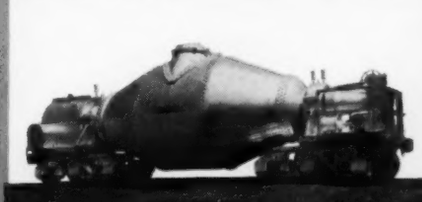
# GRANITE CITY STEEL TALKED TO TREADWELL...



...about their requirements for mixer cars of various sizes and capacities. Designing equipment to exact specifications is standard **TREADWELL** procedure, and since 1942 **TREADWELL** has designed and constructed 15 hot metal mixer cars for Granite City Steel—each especially adapted to its individual function. Granite City Steel has purchased 4 **TREADWELL** 315-cu. ft. capacity cinder cars. For handling equipment that promotes operating efficiency, **TALK TO TREADWELL**, soon.

**M. H. TREADWELL COMPANY, INC.**
140 CEDAR ST. NEW YORK 6, N. Y. ■ WOrth 4-3344
SALES OFFICES:
1015 Farmers Bank Building, Pittsburgh 22, Pa.
208 South La Salle Street, Chicago 4, Illinois
SALES REPRESENTATIVES:
Shook & Fletcher Supply Company
1814 First Avenue North, Birmingham, Alabama
R. A. Ashby, 7 Live Oak Way, Kentfield, Calif.

**TREADWELL**
MIXER CARS

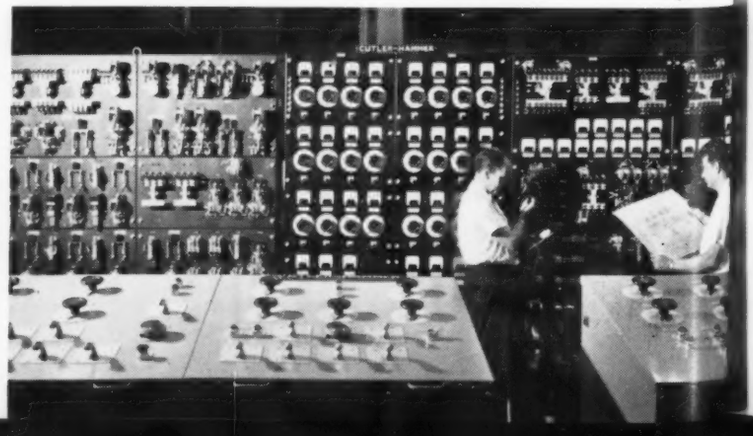


ONE OF GRANITE CITY STEEL'S FIFTEEN TREADWELL MIXER-TYPE HOT METAL CARS

TR 47 ENGINEERING AND DESIGN SERVICES: Cost Studies—Preliminary Engineering—Complete Engineering and Design for New Plants or Expansion

**Call in the C-H man early!** Broad experience in all phases of systems control design means the Cutler-Hammer man brings a knowledgeable eye to your particular control problems. Whether your requirements call for a unique solution, as this Granite City job did, or a more standardized system, call Cutler-Hammer.

**Cutler-Hammer Test Floor.** Here, complete factory tests of systems control prior to shipment insure faster installation, more trouble-free start-ups. Analog computer-simulator can test engineering solutions before construction; simulate response of any motor or machine to aid in actual factory tests.



*What's new in systems control?*

# New Cutler-Hammer synchro tower position control smooths operation of Granite City tinning line

## *New approach provides stepless tower movement, cuts maintenance required by older systems*

Stepless control over the entire range of tower movement is provided for the first time in the steel industry by Cutler-Hammer. In addition, a continuous visual indication of the exact looper position is always available to the operator.

Both entry and exit towers of the tinning line at Granite City Steel Company in St. Louis utilize this new synchro control.

### Less Maintenance

Synchro control eliminates the steps, and greatly reduces the amount of maintenance commonly associated with photoelectric tower control systems. Results? Better control, smoother operation of entry and exit sections, which is echoed in better control of the tinning and cleaning section and of the entire line.

The tinning section is where accurate and synchronized speed regulation provided by the systems control engineer contributes to obtaining the ultimate in tin coated strip.

The complex array of continuous process equipment on the Granite City line is driven by 85 D-c motors totalling 1044 hp and is powered by 13 D-c generators. These 98 rotating machines are tied together by a control system which includes 15 static type regulators to insure superior line performance.

Among the reasons for recent Cutler-Hammer achievements in continuous process control is a standard factory pretest procedure, plus an analog computer-simulator that can help engineers test solutions before construction. *You get more benefits when you call in your Cutler-Hammer systems man early in your planning.*

### What's new at Cutler-Hammer?

Recent leadership in tinning line control is matched by other Cutler-Hammer systems automation in dozens of continuous process lines. Look for more "firsts" from Cutler-Hammer . . . we've geared up with new production facilities, new engineering talent . . . a *new desire* to help the primary metals industry meet the challenge of the sixties! Call in your Cutler-Hammer man early in your planning.

*WHAT'S NEW? ASK...*

**CUTLER-HAMMER**

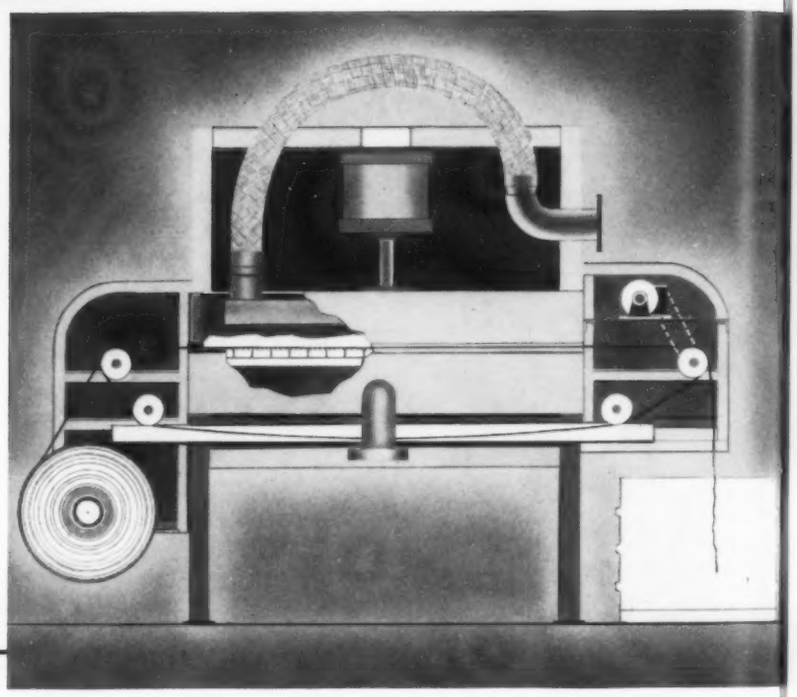
**Cutler-Hammer Inc.,** Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. • Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

# LOOK WHO'S GETTING ALL THE DIRT!

LOOK WHO'S GETTING ALL THE DIRT!

Look Who's Getting All The Dirt!

**(Hydromation's New Filtering System At The Granite City Mill)**



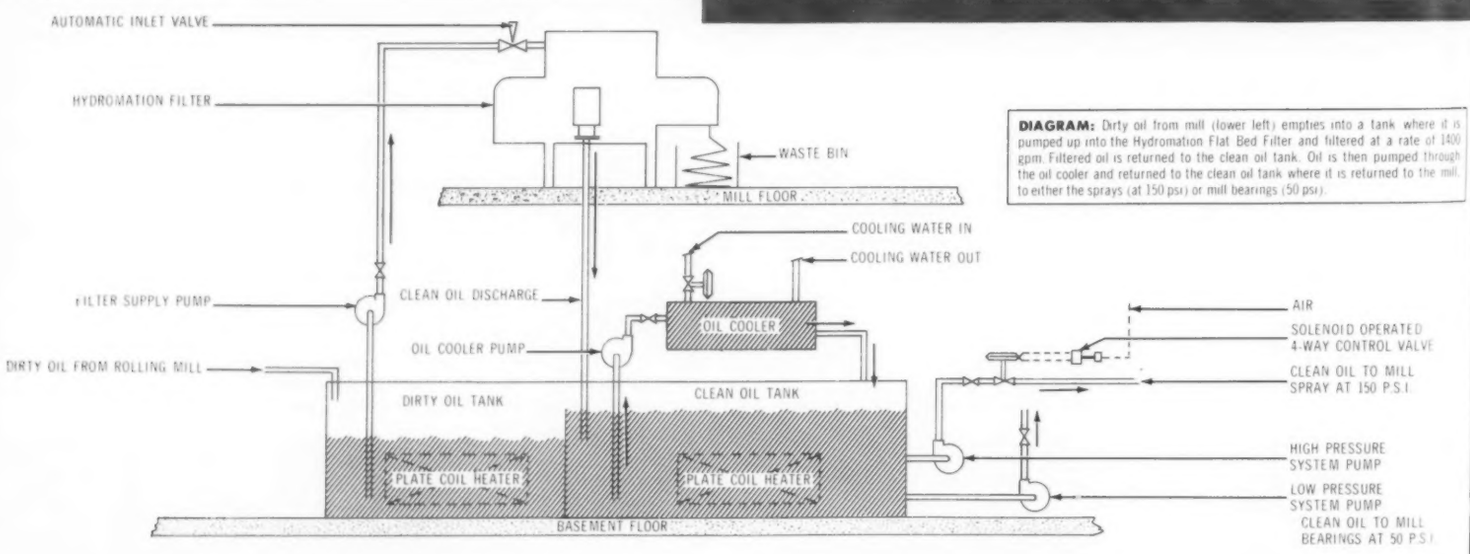



**DIAGRAM:** Dirty oil from mill (lower left) empties into a tank where it is pumped up into the Hydromation Flat Bed Filter and filtered at a rate of 1400 gpm. Filtered oil is returned to the clean oil tank. Oil is then pumped through the oil cooler and returned to the clean oil tank where it is returned to the mill, to either the sprays (at 150 psi) or mill bearings (50 psi).

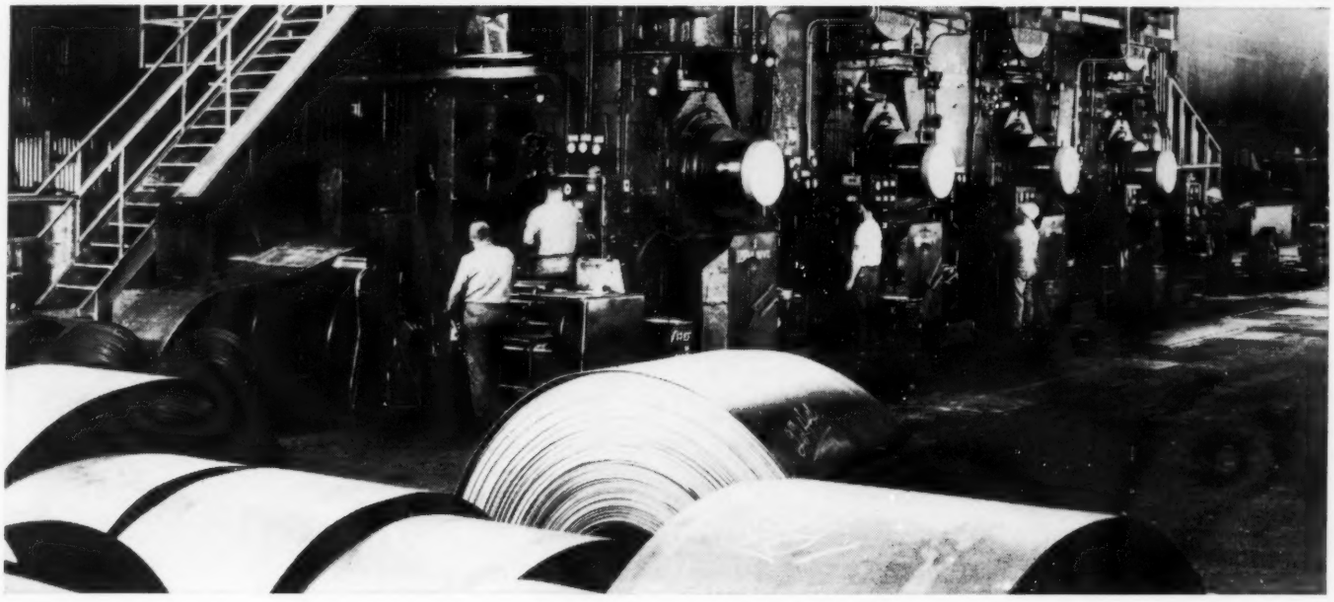
Removing dirt from lubricants and coolants used in rolling mills means a big savings in overall efficiency on Granite City Steel Company's new Waterbury Farrel Sendzimir Mill near St. Louis, Mo. Here's why:

Removal of solids from the oil prevents dents and scratches which cause downgrading or rejection of material. Quality control is easier and more effective by removing contaminants from the lubricant before it is fed into the nest of work and back up rolls in the mill. Rolls run longer before they need grinding, and cleaner lubricants reduce wear on internal mill parts. Plugged sprays are eliminated and the service life of lube oil or coolant is increased.

If you would like to increase efficiency and cut many "hidden" costs in your mill operation, why not check with Hydromation . . . manufacturers of specially engineered, completely automatic filtering systems used throughout the world for rolling mill applications.

**HYDROMATION FILTER COMPANY**
**39201 Amrhein Rd., Livonia, Michigan**

# ...during 89 times in the mill Heppenstall Sleeve #1727 rolled 921,863 tons



Four stand cold strip mill of Granite City Steel Company, Illinois . . . one of the most powerful tandem cold reduction mills in the U.S.

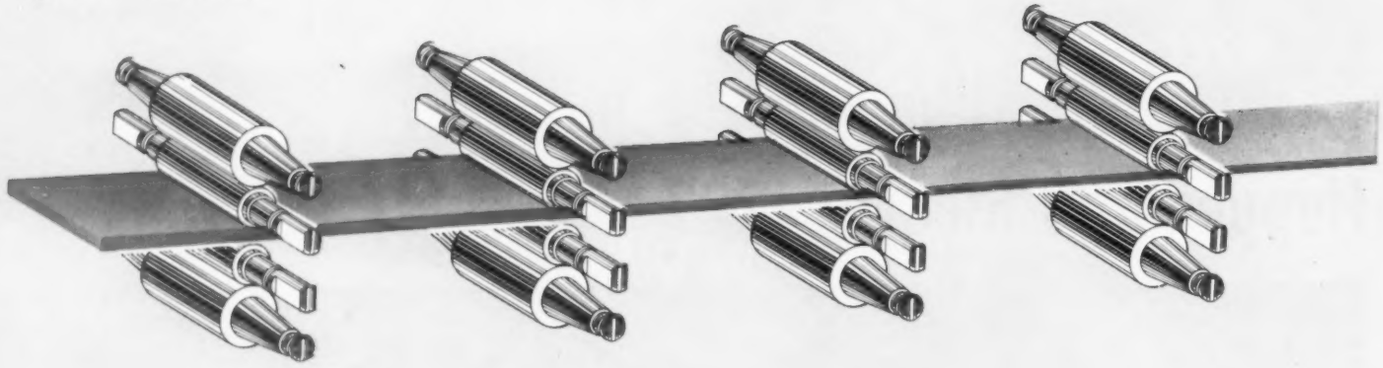
This performance in the GRANITE CITY STEEL PLANT reflects the high quality and durability of Heppenstall and Midvale-Heppenstall mandrel-forged sleeves . . . tempered to meet the exact hardness specification. For more information about Heppenstall products used throughout the steel industry . . . from open hearth to finished product . . . call your Heppenstall Representative, or write us direct.

**HEPPENSTALL COMPANY** • PITTSBURGH 1, PA.
Plants: Pittsburgh & New Brighton, Pa. • Bridgeport, Conn.

**MIDVALE-HEPPENSTALL COMPANY**
NICETOWN, PHILADELPHIA 40, PA.

Die Blocks • Forgings • Back-Up Roll Sleeves • Rings • Industrial Knives
Materials Handling Equipment • Pressure Vessels • Hardened and
Ground Steel Rolls • Vacuum and Consumable Electrode Melted Steels

(CONTINUOUS)



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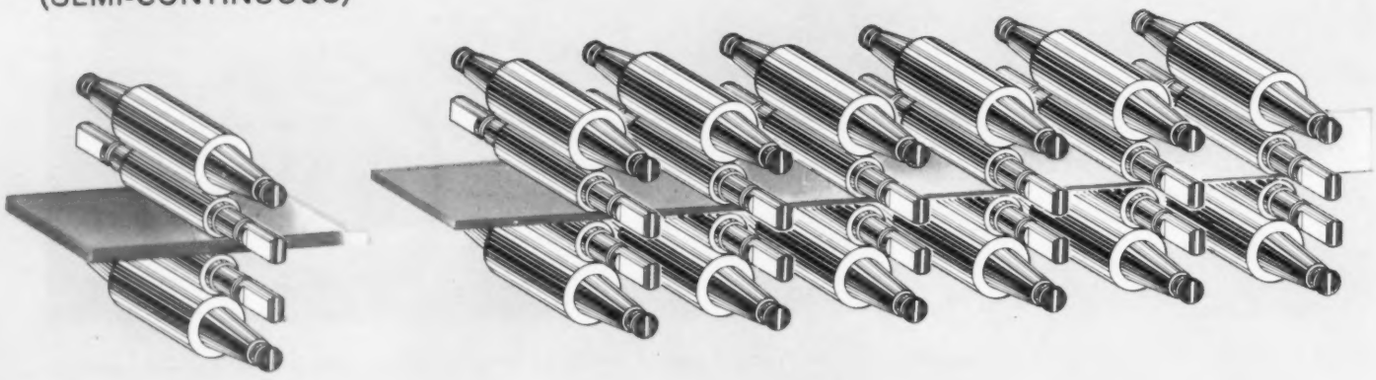


*Mack-Hemp rolls are right for every mill...*

# IN HOT STRIP MILLS...

These Mack-Hemp steel and iron rolls have met every test the nation's hot strip mills have put to them. They are:

**Technalloy**... First heavy-duty cast alloy steel roll with high strength. An economical back-up roll for all 4-high stands, and a fine work roll in 2-high roughing stands.

**Technikrome** ... A high-carbon alloy steel roll of wide versatility. A good roughing stand work roll under average operating conditions.

**Nichillite**... A definite chill alloy iron utility roll providing high hardness and wear resistance. Recommended for finishing work under good-to-average conditions.

**Nironite A and AX**... Nickel chromium alloy grain iron rolls with high strength and deep hardness penetration.

**Nironite F**... High alloy grain iron roll, double-poured for maximum core and neck strength, and specially heat treated to increase resistance to thermal shock and spalling.

## KEY TO MODERN HOT STRIP ROLLING...

| | CONTINUOUS | | SEMI-CONTINUOUS | FINISHING TRAIN | | |
|---|---|---|---|---|---|---|
| | Broadside Mill | Roughing Stands | Reversing Roughing Stand | Stands 1 & 2 | Stands 3, 4 & 5 | Finishing Stand |
| **WORK ROLLS** | | | | | | |
| Good Conditions | Nironite AX 68 Shore | Nironite AX 68 Shore | Nironite F 68-72 Shore | Nironite F 74 Shore | Nironite F 78 Shore | #4 Nichillite 80 Shore |
| Average Conditions | Nironite A 65 Shore | Technikrome 40 Shore | Nironite F 68-72 Shore | Nironite F 74 Shore | Nironite F 78 Shore | #6 Nichillite 80 Shore |
| Severe Conditions | Technalloy 40-45 Shore | Technalloy 45 Shore | Technalloy 42-48 Shore | Superalloy 48-50 Shore | Nironite F 78 Shore | Nironite F 80 Shore |
| **BACK-UP ROLLS** (in 4-HI STANDS) | Technalloy 48 Shore | Technalloy 48 Shore | Technalloy 48 Shore | Technalloy 48 Shore | Technalloy 48 Shore | Technalloy 48 Shore |

**Midland Superalloy** . . . A nickel-chromium-molybdenum alloy steel roll especially developed to withstand fire cracking and breakage under severe operating conditions.

• • •

In short, there is a Mack-Hemp roll that is just right for each stand and each set of operating conditions. This tailoring of the rolls to the mill is one of the important reasons why *you get more tonnage from the rolls with the striped red wabblers.*

**MACKINTOSH-HEMPHILL**

**DIVISION OF**

**E. W. BLISS COMPANY**

**Pittsburgh and Midland, Pa.**

MACKINTOSH-HEMPHILL DIVISION · PITTSBURGH U.S.A. · BLISS

**Mackintosh-Hemphill Division of E. W. Bliss Co. is proud to be numbered among the suppliers of the Granite City Steel Co.**

# INTRODUCING

## THE NEW DUAL HALLDEN SYNCHRONIZED *FLYING* PRESS AND SHEAR WITH INTEGRAL LEVELLER

- **Continuous Uniform Feed Directly from the Coil**
- **Open Construction for Easy Accessibility**
- **Unlimited Cut Length Range**

Latest Addition to the World Reknown Family of

**HALLDEN FLYING CUTTING MACHINES**

Equipped with micrometer adjustments for synchronization and feed while the machine is in motion

Engineered and built to meet individual requirements for blanking, shape or square type cutting, or any combination —

Write for design survey of your specific requirements.

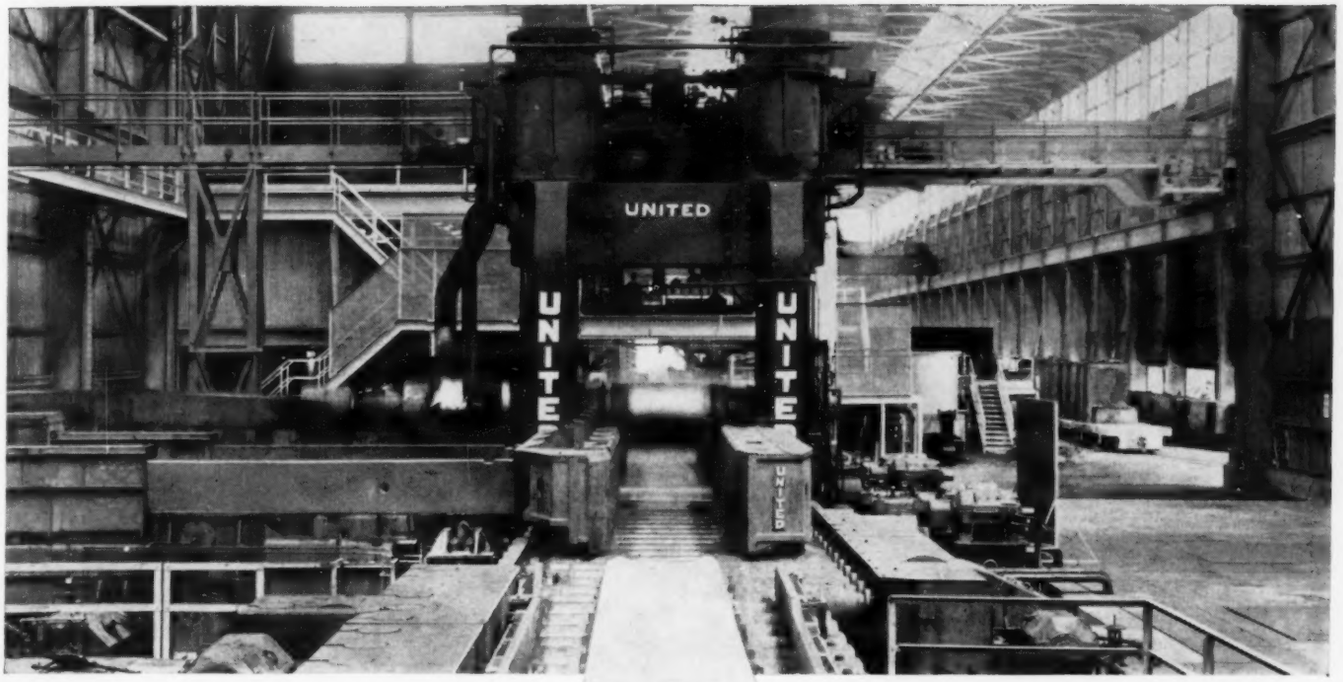
*DESIGNED AND BUILT BY*

# HALLDEN

*THE SHEARING SPECIALISTS*

**THE HALLDEN MACHINE COMPANY • THOMASTON, CONNECTICUT**

Associates: The W. H. A. Robertson & Co., Ltd., Bedford, England




# *Granite City slabbing mill rolls over four million ingot tons without loss of a single bearing*

## *. . . thanks to dependable* FARVAL DUALINE CENTRALIZED LUBRICATION

Here's what the record book shows: Over a 4½-year period, this modern rolling facility at Granite City Steel Company delivered 4,420,000 ingot tons—*and not a single bearing failed due to lack of lubrication!*

That's because 19 Farval systems—both manual and automatic—kept an around-the-clock watch on 940 points of lubrication to help maintain production at high levels. No measuring valves were taken apart, cleaned or repaired. As a matter of fact, no money was spent for maintenance of the Farval systems during this record 54-month period.

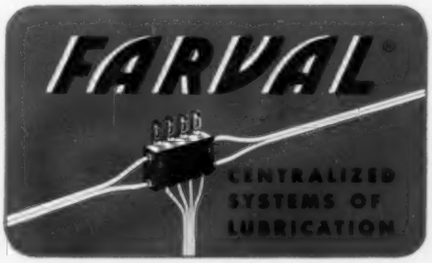
You'll generally find Farval on the job wherever steel is made or worked. Literally thousands of systems are daily protecting bearing life of rolling mill machinery. Many such Farval systems have chalked up service records of 20 to 25 years . . . and still going strong.

Find out how Farval can help reduce bearing wear on all types of industrial machines and equipment. Write for our latest literature which gives the complete Farval story, or contact your local Farval representative.

Three of 7 heavy-duty automatic, time clock controlled Farval Central Stations that serve Granite City Steel's Slabbing Mill

**Farval Division**
Eaton Manufacturing Company
3278 East 80th Street • Cleveland 4, Ohio

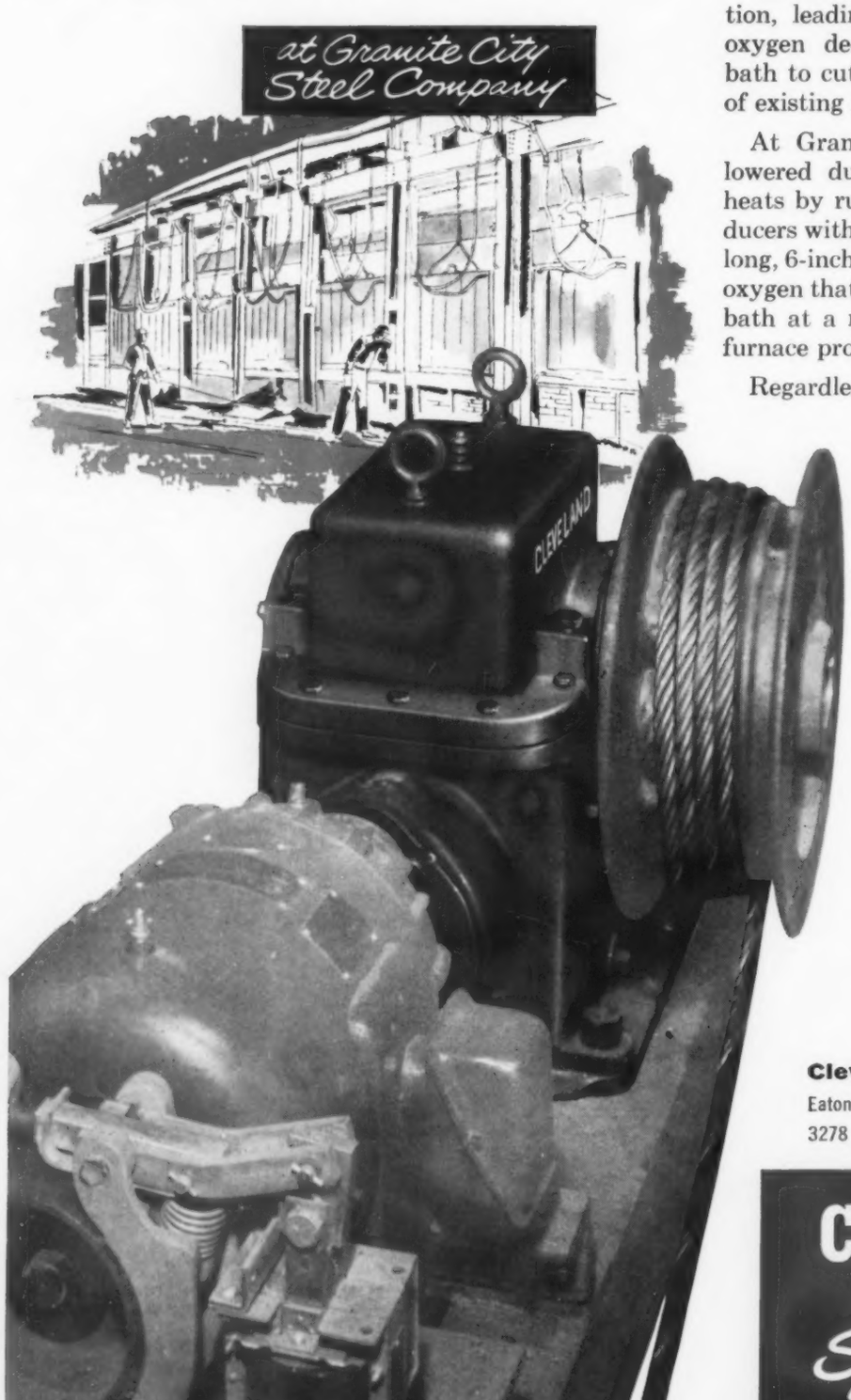
Farval Studies in Centralized Lubrication No. 256



***rugged, dependable***

# CLEVELAND WORM GEAR SPEED REDUCERS

***manipulate lances used in high-production oxygen steel making process...***




With today's emphasis on increased production, leading steel producers are turning to oxygen decarburization of the open-hearth bath to cut heat working time—boost output of existing furnaces.

At Granite City, oxygen roof lances are lowered during the working of open-hearth heats by rugged 100AT Cleveland Speed Reducers with helical attachments. These 13-foot long, 6-inch diameter lances deliver high purity oxygen that reduces carbon content of the steel bath at a more rapid rate—greatly increases furnace production.

Regardless of shock or load, where motor power must be transmitted through a right-angle drive, smoothly, efficiently, and without interruption, Clevelands are the answer. Look around the next time you're in a steel plant and note how many of these versatile drives are in use.

Why not write today for your free copy of our most recent illustrated literature that shows the latest developments in the field of worm gearing. Or better yet, contact your nearest Cleveland representative and get the complete facts.

**Cleveland Worm & Gear Division**
Eaton Manufacturing Company
3278 East 80th Street • Cleveland 4, Ohio

**CLEVELAND**
**Worm Gear**
*Speed Reducers*

# An Analysis of the Stresses and Deformations in Work Rolls

by CARL F. ZOROWSKI, Assistant Professor, Mechanical Engineering
and ALVIN S. WEINSTEIN, Assistant Professor, Mechanical Engineering
Carnegie Institute of Technology, Pittsburgh, Pa.

*Roll flattening changes the work roll's arc of contact—analysis of the contact arc permits a precise examination of the maximum shear stresses involved during rolling.*

A METHOD* is presented for determining the stress distribution and surface deformations due to normal pressures on work rolls in strip rolling. This method is used to investigate the effect of varying backup loads on the roll surface deformations in the strip contact region. These deformations are compared with those predicted by Hitchcock's analysis.

This technique is also used to investigate the stress distribution within the work roll for a typical friction-hill pressure distribution. Comparisons are made between this result and the stresses arising from several Hertzian pressure distributions for the same total load.

The work roll deformation in the contact region has long been considered a problem of importance in the analysis of the mechanics of rolling. The effect of roll flattening is to increase the arc of contact with a consequent change in the predicted values of the rolling load and torque.

One of the earlier and perhaps best known techniques for predicting roll flattening is the work of Hitchcock,[1]† which assumes that the pressure distribution over the contact arc is elliptical and that the resulting roll flattening is given by a circular arc of increased radius.

Orowan[2] has pointed out that the assumption of an elliptical pressure distribution does not result in a compatible solution for the deformations of the strip and the roll in the contact region. Orowan[2] also suggested that the work of Michell[3] might be used to obtain an improved analytical approach to the roll-flattening problem, which would result in a compatible solution for the deformations of the strip and the roll.

Jortner[4] applied Michell's work to develop a technique for determining the deformations on the surface of a cylinder subjected to any arbitrary 2-dimensional normal pressure distribution over the contact region. Jortner's application of this technique in the study of the mechanics of cold strip resulted in a compatible solution for the strip and roll deformations in the contact regions. However, Jortner's method requires that the cylinder (work roll) be placed in equilibrium by the same pressure distribution as occurs in the contact region, which implies that the pressure distribution between the backup roll and work roll is the same as that between the work roll and the strip. The work of Hertz[5] shows that the pressure distribution between two cylinders in contact does not resemble a friction-hill pressure distribution.

This paper presents a method for determining the surface deformations of a cylinder not restricted by the limitation of Jortner's analysis. The method developed here permits the handling of any arbitrary 2-dimensional normal pressure distribution on the surface of the cylinder as long as the resulting pressure distribution is in equilibrium. Thus the surface deformations of the work roll can be determined from the pressure distribution in the arc of contact kept in equilibrium by the actual pressure distribution caused by the backup roll.

In addition, this more accurate consideration of the normal pressures applied to the work roll surface permits a more realistic determination of the stress state in the roll. A technique for calculating this stress state once the normal pressure distribution on the roll surface has been specified is included.

These techniques are used to investigate several problems of interest relating to surface deformations and stress distribution. The effect of varying backup loads on the roll surface deformations in the strip contact region is determined. The surface deformations due to a typical friction-hill pressure distribution are obtained and compared with Hitchcock's result for the same total load. The friction-hill pressure distribution will from here on be referred to as the compatible pressure distribution.

Using this same typical pressure distribution, stress variations in the roll are shown. This state of stress is compared with that predicted assuming an elliptical pressure distribution of the Hertzian type. Three cases are investigated for this elliptical distribution for the same total load: the same arc of contact as the compatible pressure distribution, an arc of contact corresponding to a backup roll having the same diameter as the work roll and an arc of contact corresponding to a

* The work reported here was supported by a grant from the National Science Foundation.

† Numbers in parentheses refer to Bibliography at end of paper.

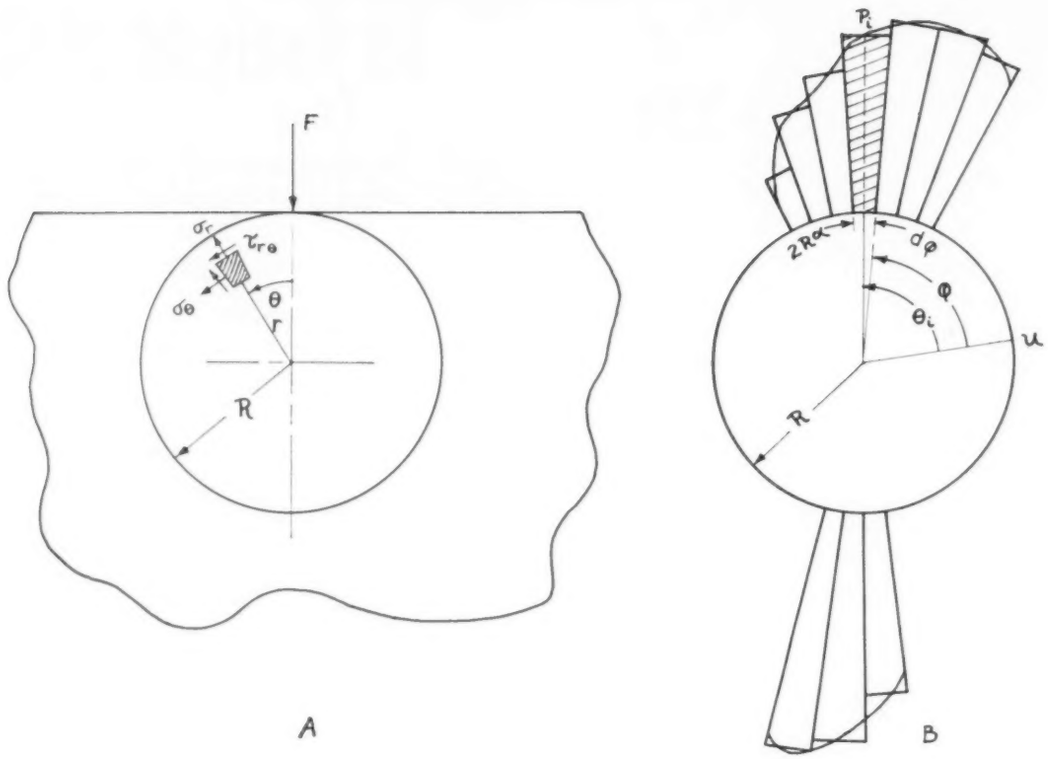



**Figure 1 — Point load on a semi-infinite plane is resolved into two components of surface stress (A). The pressure F is represented by an arbitrary self-balancing normal pressure distribution (B).**

backup roll of infinite diameter (flat plate in contact with cylinder).

## GENERAL PROBLEM ANALYSIS

The stress distribution throughout a cylinder and the resulting surface deformations due to an arbitrary 2-dimensional normal surface pressure distribution is built up from the solution for the stresses in a semi-infinite plane subjected to a concentrated force perpendicular to the surface.[3] On the surface of the cylinder where r equals R as shown in Figure 1A, the surface stresses $\sigma_r$ and $\tau_{r\theta}$ can be resolved into two components. These are a uniform hydrostatic compression and a uniform stress acting parallel but opposite to the direction of the applied load F at all points on the surface. The uniform hydrostatic compression is eliminated by simply superimposing a state of hydrostatic tension on the stresses of the semi-infinite plane problem. This results in a combined stress state of:

$$\left.\begin{aligned}
\sigma_r &= \frac{2F}{\pi}\left\{\frac{1}{4R} - \frac{(R - r\,(\cos\theta)\,(r - R\cos\theta)^2)}{(r^2 + R^2 - 2\,Rr\,\mathrm{Cos}\,\theta)^2}\right\} = \frac{2F}{\pi} f_1(r,\theta)\\
\sigma_\theta &= \frac{2F}{\pi}\left\{\frac{1}{4R} - \frac{(R - r\cos\theta)\,(R^2\sin^2\theta)}{(r^2 + R^2 - 2\,Rr\cos\theta)^2}\right\} = \frac{2F}{\pi} f_2(r,\theta)\\
\tau_{r\theta} &= \frac{2F}{\pi}\left\{\frac{(R - r\cos\theta)\,R\sin\theta\,(r - R\sin\theta)}{(r^2 + R^2 - 2\,Rr\cos\theta)^2}\right\} = \frac{2F}{\pi} f_3(r,\theta)
\end{aligned}\right\} \quad (1)$$

where the symbols are as defined in Figure 1A.

Now, if a point load is placed in equilibrium by application of point loads at other locations on the surface of the cylinder, the boundary will be stress free. This occurs because at each point on the boundary, stresses proportional to the applied loads and parallel in direction to their respective applied loads combine to give a net resultant of zero since the applied loads are in equilibrium. Equations (1) can thus be used to give the complete and correct stress distribution for an arbitrary self-balancing normal load distribution.

*Surface deformations*—The surface deformations on the cylinder for a single point load are obtained by integrating the normal strain obtained from stress equations (1) in the radial direction from the center of the cylinder to the surface assuming a plane state of strain. The result of this integration is:

$$U_R = \frac{F}{E\pi}\left\{(1 - \mu - 2\mu^2)\left[1 - \sin\theta\tan^{-1}\left(\frac{1 - \cos\theta}{\sin\theta}\right) - \sin\theta\,\tan^{-1}\cot\theta\right] + (1 + \mu)\left[\frac{1 + \cos\theta}{2}\right] + (1 - \mu^2)\,[\cos\theta\ln 2\,(1 - \cos\theta)]\right\} = \frac{F}{E\pi} h(\theta) \quad (2)$$

In order to determine the surface deformations resulting from a continuous pressure distribution, the discrete load F in equation (2) is replaced by the product of the local pressure and the infinitesimal arc length over which it acts. Then the total deformation at any point on the surface is given by summing up the contributions from each of these local pressures. This may be expressed mathematically as:

$$\mu = \int_0^{2\pi} \frac{P\,(\varphi)R}{\pi E}\,h\,(\varphi)\,d\varphi \quad (3)$$

where $P\,(\varphi)\,Rd\varphi = F$ and where $P(\varphi)$ represents any arbitrary self-balancing normal pressure distribution on the surface of the cylinder, see Figure 1B.

Unless $P(\varphi)$ is uniform or a known function of $\varphi$, then the integration of equation (3) must be performed by appropriate numerical techniques.

*Stress distribution*—The determination of the state of stress within the work roll due to an arbitrary normal pressure distribution is obtained by a technique similar to that used for finding the surface deformations.

Equations (1) represent the contribution to the stress at any point defined by r and $\theta$ in the work roll due to a single point load acting on the surface, see Figure 1A. To establish the stress at any point, due to an arbitrary equilibrium normal pressure distribution, the point load (F) in equations (1) is first replaced by the local pressure (P) multiplied by the incremental arc length over which it acts ($R\,d\varphi$). The total stress at this point is then found by summing up all of the contributions to the stress at this point due to each increment of pressure. This can be represented mathematically by the following expressions:

$$\left.\begin{aligned}\sigma_r &= \frac{2}{\pi}\int_0^{2\pi} P(\varphi)\, f_1\,(r, \varphi) R d\varphi \\ \sigma_\theta &= \frac{2}{\pi}\int_0^{2\pi} P(\varphi) f_2\,(r, \varphi) R d\varphi \\ \tau_{r\theta} &= \frac{2}{\pi}\int_0^{2\pi} P(\varphi)\, f_3\,(r, \varphi)\, R d\varphi\end{aligned}\right\} \quad (4)$$

where $f_1$, $f_2$, $f_3$ are as given by equations (1).

Unless the form of $P(\varphi)$ is such that equations (4) can be integrated directly, a numerical technique must be applied to their evaluation. An alternate method of solution for the stress distribution in a cylinder subjected to an arbitrary 2-dimensional surface loading is given by Wang.[6] However, the numerical evaluation of equation (4) using the authors' techniques is considerably less cumbersome than the numerical evaluation of Wang's solution. The methods used for numerical evaluation of equations (3) and (4) for the results presented in this paper are not given here but a complete description of these methods may be obtained from the authors upon request.

## BEHAVIOR OF SURFACE DEFORMATIONS

The method of calculating surface deformations outlined in the previous section was applied to investigate the shape of the flattened roll in the region of the arc of contact. Since this method permits the consideration of any arbitrary self-balancing normal pressure distribution applied to the roll, the first problem considered was the sensitivity of the deformations in the contact region to variations in the backup pressure distribution. A second application of the methods described was made to obtain a comparison between the flattened roll shape due to a typical compatible pressure distribution and the roll shape predicted by the Hitchcock analysis for the same rolling load.

*Effect of backup load*—A series of numerical examples were calculated to determine the effect of changing backup load on roll deformations in the vicinity of the strip. A uniform pressure of 100,000 psi over four degrees of arc on a 5-in. radius roll was assumed to represent the pressure distribution between the strip and roll. This was backed up by four uniform pressure distributions acting over one, two, three and four degrees of arc respectively, and one triangular backup distribution over four degrees was considered, see Figure 2. For each one of these five equilibrium loadings, the surface deformations over eight degrees of arc straddling the contact pressure distribution were determined.

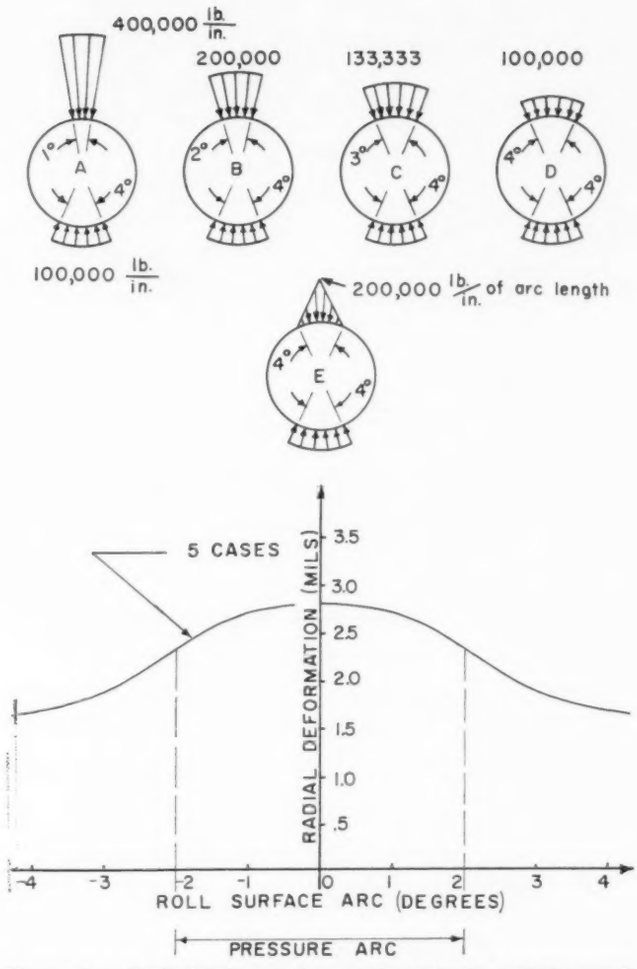



**Figure 2 — Radial deformation at the strip face of the work roll is not seriously affected by the changes in the shape of the backup roll load.**

The calculated deformation results are presented graphically in Figure 2. All five cases fall on one curve. The maximum difference in deformations for the five cases was of the order of one part in 1000. Thus it can be concluded that the shape of the backup load has a negligible effect on the deformations in the vicinity of the strip provided the arc of contact of the pressure distribution is small compared to 360 degrees.

To support this conclusion further an additional numerical example was considered in which the contact pressure distribution was taken to be a typical compatible pressure distribution. The pressure distribution used for the numerical calculations was taken directly from one of the equilibrium pressure distributions obtained by Jortner[4] in his analysis of cold strip rolling. The specific example was a 30 per cent cold reduction of a steel strip with an initial gage of 0.383 in. through a 4-high mill with 10-in. work and backup rolls. The strip had been previously reduced by 40 per cent and received no annealing previous to the additional 30 per cent reduction. As mentioned in the introduction, Jortner's technique results in the prediction of a pressure distribution which assures the compatibility of the strip and roll deformations in the contact region.

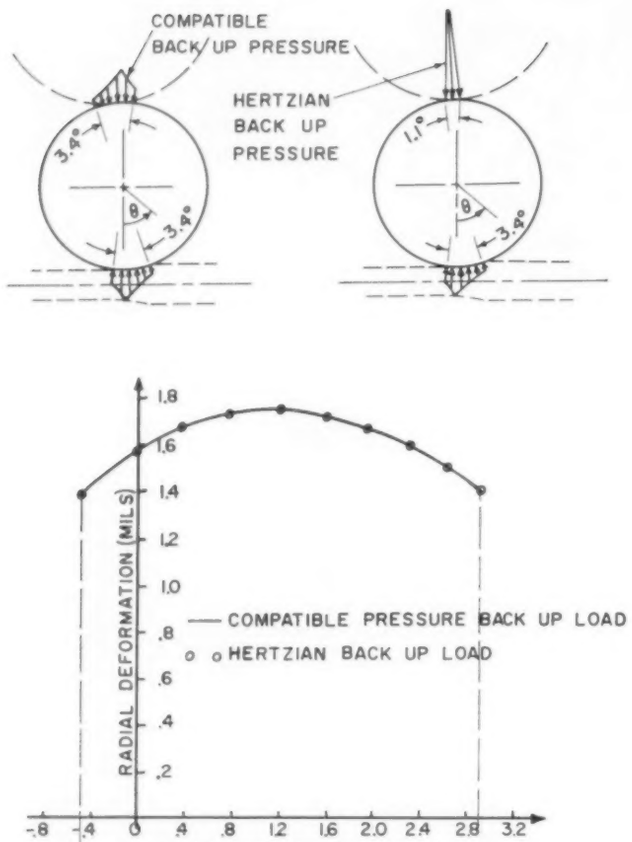



**Figure 3 — Deformation of the work roll in the contact region is the same whether the Hertzian or the compatible pressure distribution method is used.**

Using the compatible pressure distribution and assuming a Hertzian[5] pressure distribution for the backup roll, the deformations were calculated for the work roll in the contact region. These results are plotted in Figure 3 with the deformations obtained by Jortner in which he assumed the backup pressure distribution to be of the same shape as the contact distribution. Figure 3 again shows both results on one curve indicating no observable difference due to the change in the backup load.

It can be concluded from the results presented in Figure 3 as well as in Figure 2 that a variation in the backup load produces no significant change in roll flattening in the arc of contact.

*Comparison of flattened roll shapes*—The flattened roll shape in the arc of content for the friction-hill distribution is obtained by subtracting the radial deformation as shown in Figure 3 from a circular arc of radius five in. The result is shown in Figure 4 as the curve labeled compatible roll surface. Also presented in this figure are the flattened roll surface as predicted by Hitchcock's analysis[1] for the same rolling load and the shape of the undeformed roll. All three curves are plotted with their respective roll centers on the same vertical axis. Both the compatible and the Hitchcock roll surfaces are plotted relative to the exit strip height. If the strip is removed from between the rolls and the roll center remains fixed at the location of the roll center for the compatible roll surface the shape of the undeformed roll is as shown in Figure 4. In other words the undeformed roll surface represents the relaxed condition of the compatible roll surface with the roll center fixed and the strip removed.

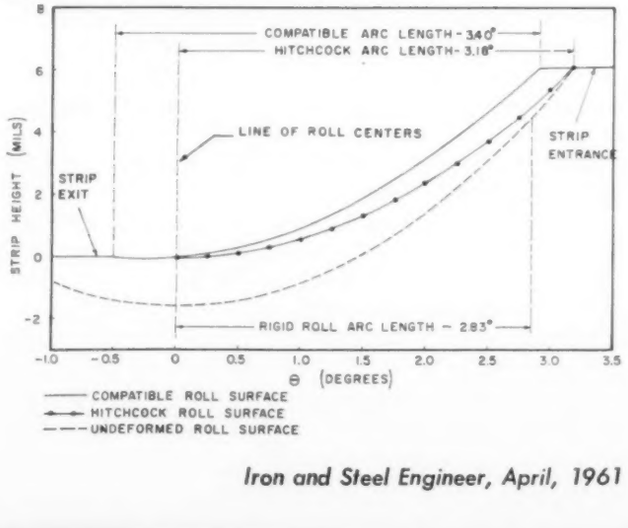
From Figure 4 it can be seen that flattening of the roll surface has a significant effect on the total arc of contact. The Hitchcock analysis predicts a 12.4 per cent increase in arc length while the compatible roll surface shows an increase of 20.1 per cent over the undeformed roll arc length. This indicates that there is a considerable difference in arc length for the same total load as predicted by these two methods of analysis. If the Hitchcock roll surface curve is shifted laterally to the left so that the contact entrance points are coincident, the maximum difference between these curves is of the order of six per cent of the radial deformation of the roll due to the compatible pressure distribution. It is evident that major differences exist between the two solutions but no attempt is made in this paper to evaluate the effect of these differences in predicting total rolling load and torque. However, it should be noted that the differences described apparently arise from the assumptions inherent in the Hitchcock analysis which do not permit the conditions of continuity and equilibrium between the strip and roll to be satisfied simultaneously. On the other hand, the flattened roll surface predicted by the compatible pressure distribution does satisfy continuity and equilibrium simultaneously at all points in the contact region, and thus represents a more accurate description of the deformations.

## BEHAVIOR OF WORK ROLL STRESSES

The method outlined in the general analysis for the calculation of stresses in the work roll was applied to determine the resulting stress states arising from a number of different normal pressure surface loadings. The following four loadings were investigated:

1. Compatible pressure distribution. The equilibrium friction-hill distribution used in the previous section for surface deformation calculations.
2. Elliptical pressure distribution. An elliptical distribution of pressure having the same arc of contact and giving the same total load as the compatible pressure distribution.
3. Finite roll Hertzian distribution. An elliptical distribution of pressure arising from the Hertz theory for two cylinders in contact giving the backup load due to a 10-in. backup roll. This corresponds to the backup

**Figure 4 — The compatible pressure method satisfies simultaneously the equilibrium and continuity requirements at all contact points in the system.**



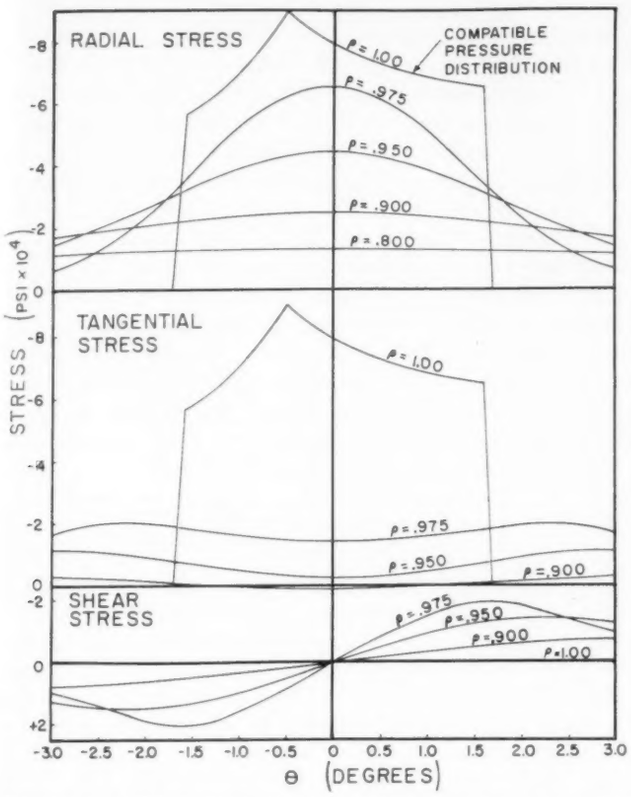



**Figure 5 — With compatible pressure loading the peak stresses are not symmetrical with regard to the centerline of the roll.**

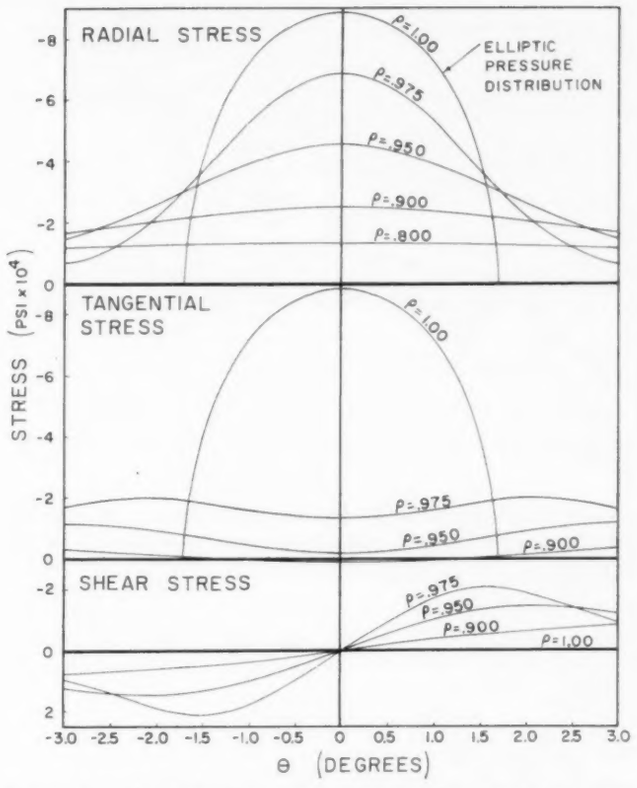



**Figure 6 — High stress values occur only in the roll in an area 1/4 to 3/8 in. deep below the arc of the contact.**

condition in the problem from which the compatible pressure distribution was obtained.

4. Infinite roll Hertzian distribution. A second elliptical distribution obtained from the Hertz theory giving the backup load due to an infinite backup roll. This distribution along with the finite roll Hertzian distribution provide bounds on the stresses in the vicinity of backup contact arc for any size backup roll exceeding the diameter of the work roll.

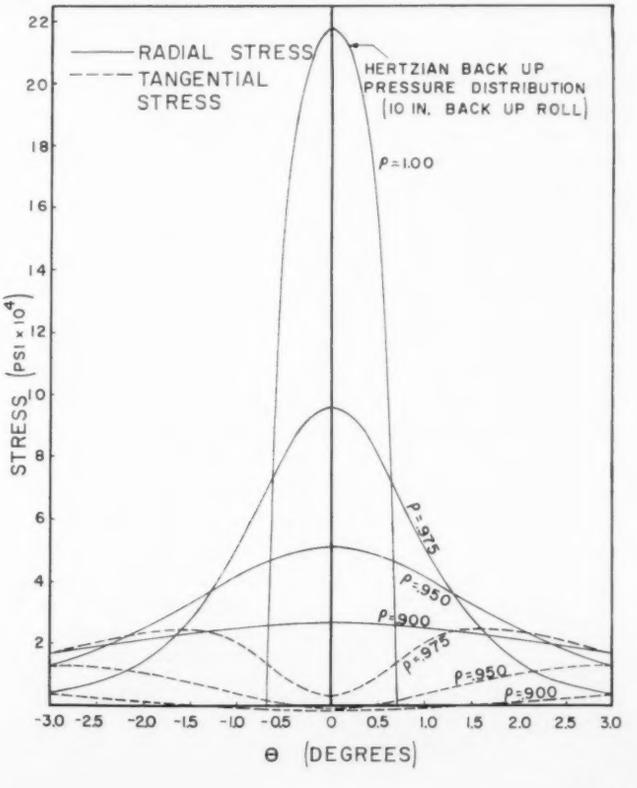
All three stress components, $\sigma_r$, radial stress, $\sigma\theta$, tangential stress and $\tau_{r\theta}$, shear stress were investigated in the vicinity of the pressure contact arc and 90 degrees away from the center of the pressure loadings. In the vicinity of the pressure loadings the stresses were determined over six degrees of arc length at several depths near the surface. The stresses were also calculated along the centerline of the loading and at 90 degrees from the center of the loading from the surface to the center of the roll.

In Figure 5 are plotted the variation of the stress components near the surface of the roll under the compatible pressure loading. At the surface, where $\rho$ which is r/R is equal to one the radial and tangential stresses are equal and are given directly by the pressure loading. The tangential stress at the surface is zero everywhere outside the loading area and the shear stress is identically zero at all points on the surface.

It may be noted that the decay of all three stress components with depth occurs very rapidly especially in the case of the tangential stress. It should also be noted that the asymmetry of the compatible distribution disappears very quickly below the roll surface.

In Figure 6 are plotted the variation of the stress components near the surface of the roll under the elliptical pressure distribution. This case was considered to determine the sensitivity of the stress near the surface under the pressure loading to variation in the shape of the pressure distribution. The arc length and total load are the same as those in the compatible pressure distribution. A comparison of Figures 5 and 6 shows that for $\rho \leq 0.975$ the difference between the two stress

**Figure 7 — Using the finite roll length Hertzian method, rapid stress decay occurs, both when moving away from the contact arc and with increasing roll depth.**



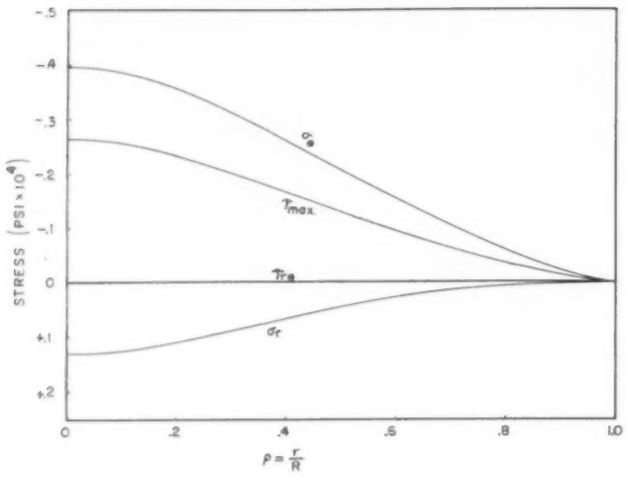



**Figure 8 — Stresses at 90 degrees from the arc of contact are almost the same for the four types of loading investigated.**

distributions is indistinguishable. For $\rho < 0.975$ as the surface is approached the radial and tangential stresses must approach the actual surface pressure distribution.

In Figure 7 are plotted the radial and tangential stresses near the surface of the roll under the finite roll Hertzian distribution. The behavior of these stress components is similar to that of the stresses in Figures 5 and 6, that is, they experience the same type of rapid decay with depth. A comparison of Figures 5, 6 and 7 shows that not only do the stresses decay rapidly with depth but they also decay very rapidly away from the contact arc of the pressure loading.

The stress components for the infinite roll Hertzian distribution in the vicinity of the loading have not been presented because of their similarity to the distributions shown in Figure 7. However, the behavior of the peak stresses along the center line of the load are presented later.

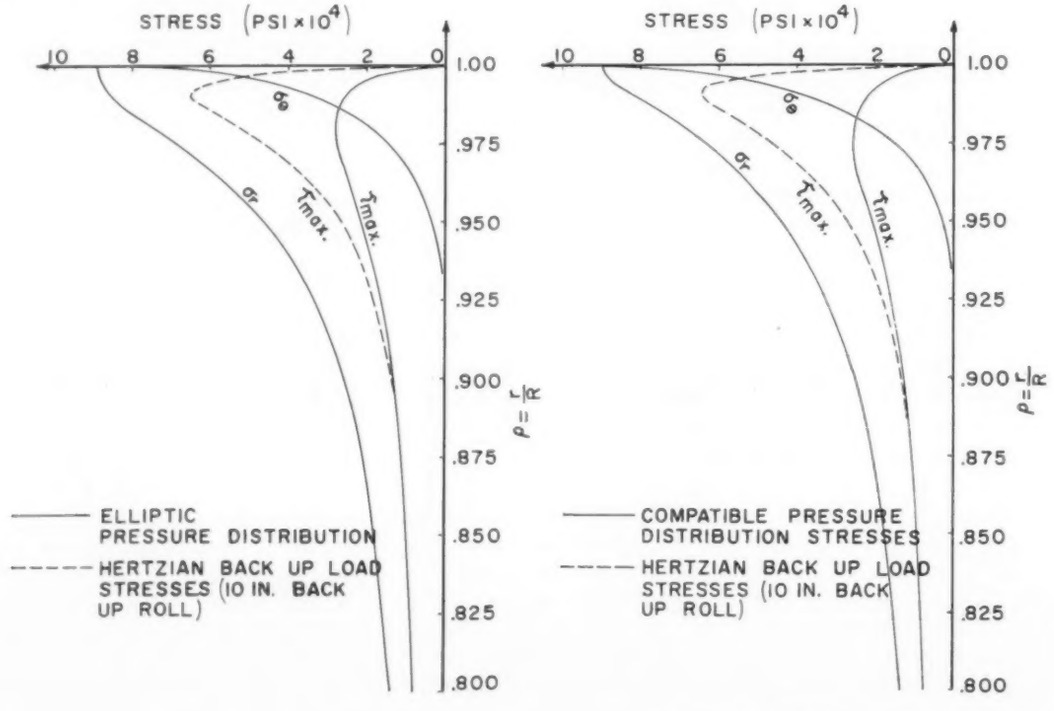
In Figure 8 are shown the variation of the three stress components and the maximum shearing stress along the radius 90 degrees from the center of all four loadings. As might be expected from the decay of the stresses in Figures 5, 6 and 7, all four loadings give essentially the same stress distributions. The maximum variation for any stress from all four loadings was considerably less than one per cent. This result would be anticipated from the consideration of St. Venant's principle.

In Figures 9 and 10 are plotted the variation of the radial and tangential stress components along the radius of the roll directly beneath the peak pressure of each loading. In addition the maximum shear stress at this same location is included in these figures. The rapid decay of the stress components with depth is dramatically shown in each of the stress distributions. For $\rho <$ 0.900 the four stress distributions are indistinguishable.

The peculiar variation of tangential and radial stress near the surface gives rise to a peak in the maximum shearing stress just below the surface. The maximum shear stress variation from the finite roll Hertzian load distribution, Figure 10, has been superimposed on the stress distributions arising from the elliptic and compatible pressure distributions to indicate the range of the peak values of the maximum shear stress the roll undergoes. From the use of Figures 8 and 9 the behavior of the maximum shear stress for each revolution of the roll can be deduced.

For the example considered (4-high mill, 10-in. diameter work and backup rolls, 30 per cent reduction of 0.383-in. gage steel strip) the variation in maximum shear stress in the work roll would be as follows: In the strip contact region the maximum shear is 25,500 psi, see Figure 9. This value decreases to essentially zero when the roll has rotated through 90 degrees, see Figure 8. A further rotation of 90 degrees brings the stress point under the backup load where the maximum shear increases to 64,000 psi (see Figures 9 and 10). As the roll rotates through another 90 degrees the peak shear stress again reduces to essentially zero, see Figure 8. The last quarter turn of the roll brings the stress point back under the strip contact pressure distribution where the maximum shear stress again re-

**Figure 9 — Stress distribution curves permit computation of the stress at any point in the roll at any time during rotation.**



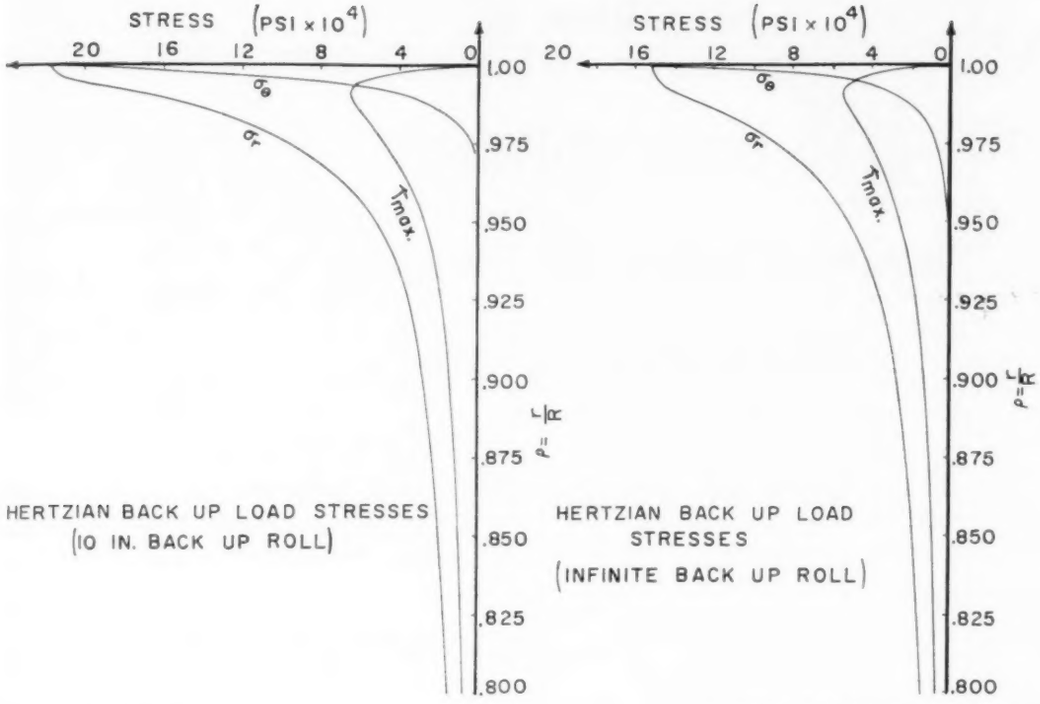



**Figure 10 — Plotted stress distributions agree with the results given by Hertz, though the methods of calculation are different.**

turns to 25,500 psi.

From Figure 10 it can be seen that even if the diameter of the backup roll is increased the maximum shear stress experienced by the work roll under the backup load does not change appreciably. The decrease in this maximum shear stress from a backup roll of 10-in. diameter to a backup roll of infinite diameter is only from 64,000 to 54,000 psi.

It is of interest to note that the stress distribution given in Figure 10 for the finite roll Hertzian distribution agrees with the results given by Hertz[5], even though the methods of calculation are different.

## SUMMARY

A method has been outlined for the calculation of surface deformations and stress distributions in cylinders subjected to any arbitrary 2-dimensional equilibrium surface pressure distribution. The application of this method to a number of specific examples has led to the following results:

1. Variation of the distribution of the backup load on a work roll has a negligible effect on the surface deformation in the region of the strip contact.

2. The roll flattening predicted by the Hitchcock analysis shows significant variations in radial deformation and length of contact are compared to that given by the more accurate analysis presented here.

3. The variation in radial, tangential and shear stress in the work roll has been presented for several different surface loadings.

4. The variation of maximum shear stress in one revolution of the work roll for a specific example has been described.

The investigations reported here have not considered the effect of shearing stresses applied to the surface of the work roll. Work is presently being carried out to include this effect on both the surface deformations and stress distributions.

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6. "Applied Elasticity," by C. T. Wang, McGraw Hill Book Co., 1953, pp. 198–200.

# Discussion

PRESENTED BY

**A. A. BRADD, Roll Coordinator, Midvale-Heppenstall Co., Nicetown, Philadelphia, Pa.**
**CARL F. ZOROWSKI, Assistant Professor, Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.**

**A. A. Bradd:** According to the authors' curves, all three types of stresses decay to low levels as we go beneath the surface. Unfortunately, we sometimes see a failure in a roll that starts at the bore where, according to these curves, there should be practically no stress.

**Carl F. Zorowski:** There is a good possibility that the type of failure referred to may come about due to some imperfection in the roll itself. In large castings of the type used for rolls there may exist inclusions or other material discontinuities at the center which give the material non-homogeneous characteristics. Such discontinuities can cause stress concentration which even under low levels of stress will give rise to the beginning of cracks. These cracks will then be propagated by the fatigue type of loading the roll is subjected to in operation until an actual failure of the roll occurs.

In our analysis we assume that the roll is a perfectly homogeneous cylinder, which contains no cracks, holes or any other discontinuity. As a result of the effects of such discontinuities do not appear. Perhaps we may be able to extend our techniques of analysis in the future to include such discontinuities. Then we may be able to predict their effect and when failure might occur. ▲

# PROGRAM

# AISE SPRING CONFERENCE

## Auspices of Rolling Mill Committee

**SHERATON-JEFFERSON HOTEL**

**ST. LOUIS, MO.**

## April 24, 25, 26, 1961

### MONDAY, APRIL 24

**8:30 am—REGISTRATION—**
**Mezzanine**

**9:00 am—ROLLING MILL SESSION—**
**Ivory Room**

Chairmen: W. E. Dittrich, Superintendent No. 2 Mills Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

Wade F. Hoffman, Superintendent, Roll Dept., Aliquippa Works, Jones & Laughlin Steel Corp., Aliquippa, Pa.

**"Photoelastic Study of Stress Distribution in Rolls,"** by L. MacNaughton, Roll Engineer, and A. A. Bradd, Coordinator of Rolls, Midvale-Heppenstall Co., Philadelphia, Pa.

**"Influence of Wear on Pressure and Stress Distribution in Rolls of Four-High Mills,"** by Dr. Kin Nee Tong, Professor; M. Sadre and M. K. Chakko, Graduate Assistants, Department of Mechanical Engineering and J. V. Latorre, Research Engineer, Dept. of Chemical Engineering and Metallurgy, Syracuse University, Syracuse, N. Y.

**"An Analysis of the Roll Flattening of a Double-Poured Roll,"** by Dr. Carl F. Zorowski, Assistant Professor, Mechanical Engineering and Dr. Alvin S. Weinstein, Assistant Professor, Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

**9:00 am—ELECTRICAL SESSION—**
**Crystal Room**

Chairmen: H. W. Dorset, Assistant Superintendent, Electrical Dept., Bethlehem Steel Co., Sparrows Point, Md.

J. F. Kostelac, Assistant Electrical Superintendent, Midland Plant, Crucible Steel Co. of America, Midland, Pa.

**"Developments in Drive Systems and Gage Control for Reversing Cold Mills,"** by K. A. Petraske and R. M. Sills, Metal Rolling and Processing Engineering, Industrial Engineering Operation, General Electric Co., Schenectady, N. Y.

## Spring Conference Chairmen

W. E. DITTRICH

W. F. HOFFMAN

H. W. DORSET

J. F. KOSTELAC

F. G. KREDEL

J. F. TEPOLT

W. M. BLOOM

C. W. DUNN

J. L. DAWSON

G. M. ESLER

S. W. STOUFFER

L. A. FUGASSI

H. A. MACHAMER, JR.

H. S. ORR

"**The Application of a Non-Contacting Measurement System for Coating Weights on Continuous Galvanizing Lines,**" by James E. Reider, Area Manager, Industrial Nucleonics Corp., Columbus, Ohio

"**Operational Results of Automatic Gage Control on a Hot Strip Mill,**" by Thomas Harmon, Jr., Chief Electrician, B. D. Houston, Assistant Superintendent, Hot Mill, Granite City Steel Co., Granite City, Ill., and R. M. Peeples, Supervisory Engineer, Control Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

## 2:00 pm—ROLLING MILL SESSION— Ivory Room

Chairmen: F. G. Kredel, Chairman of Bar Mill Committee, Republic Steel Corp., Cleveland, Ohio

Joseph F. Tepolt, Superintendent, Cold Reduction Dept., Granite City Steel Co., Granite City, Il.

"**Automatic Measurement of Bar and Structural Lengths,**" by C. H. Wexler, Associate Technologist, Instrument and Automatic Control Div., Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

"**The Sendzimir Mill for Thin Tin Plate,**" by James F. Fox, Sales Manager and A. J. Beck, Chief Engineer, Rolling Mill Div., The Waterbury Farrel Foundry & Machine Co., Div. of Textron Inc., Waterbury, Conn.

"**The Rolling of Ultra-Thin Tin Plate,**" by Dr. Morris D. Stone, Manager, Development, United Engineering and Foundry Co., Pittsburgh, Pa.

## 2:00 pm—COMBUSTION SESSION— Crystal Room

Chairmen: William M. Bloom, Chief Fuel Engineer, General Engineering, Allegheny Ludlum Steel Corp., Pittsburgh, Pa.

Charles W. Dunn, Superintendent, Utilities Dept., Fairless Works, United States Steel Corp., Fairless Hills, Pa.

"**Four-Zone Reheating Furnaces and Pusher Controls,**" by William A. Greene, Assistant Superintendent, Plant No. 2 Mills, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

"**Construction and Maintenance of Regenerative Soaking Pits with Plastic Refractories,**" by F. E. Waterman, Division Superintendent—Primary Rolling Mills and W. H. Kirwan, Superintendent, 43-In. Blooming Mill, Youngstown District, United States Steel Corp., Youngstown, Ohio

"**Simulating Thermal Response in Slab Reheating,**" by C. G. Bigelow, Vice President, Research, Selas Corp. of America, Dresher, Pa.

# TUESDAY, APRIL 25

## 9:00 am—ROLLING MILL SESSION— Ivory Room

Chairmen: J. L. Dawson, Superintendent, Blooming, Hot Strip & Rolling Mills, Aliquippa Works, Jones & Laughlin Steel Corp., Aliquippa, Pa.

G. M. Esler, Superintendent, Blooming and Hot Strip Mills, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

"**Super-Lathe for Roll Turning,**" by Jack Binns, Owner, Binns Machinery Products, Cincinnati, Ohio

"**Modernization of the Hot Strip Mill,**" by John H. Russell, Rolling Mill Operations Engineer, Steel Div., Ford Motor Co., Dearborn, Mich.

"**Acme Steel Standardizes on 10 Slab Sizes for New Hot Strip Mill,**" by W. F. Hinkle, Vice President of Engineering, Riverdale Plant, Acme Steel Co., Chicago, Ill.

## 9:00 am—MECHANICAL SESSION— Crystal Room

Chairmen: S. W. Stouffer, Director of Construction and Maintenance, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

L. A. Fugassi, Chief Engineer, Midwest Steel Corp., Div. of National Steel Corp., Valparaiso, Ind.

"**Design Considerations for Solid Bearings,**" by Bernard J. Sexauer, Bearing Engineer, National Bearing Div., American Brake Shoe Co., St. Louis, Mo.

"**The Design of Coolant Systems as Affected by Various Cold Rolled Products,**" by J. Philip Wettach, Manager, Mill Lubrication, Engineering and Construction Dept., Dravo Corp., Pittsburgh, Pa.

"**Recent Developments in Welding Techniques for Mill Maintenance,**" by R. A. Wilson, Vice President, The Lincoln Electric Co., Cleveland, Ohio

## 2:00 pm—OFF-THE-RECORD ROLLING MILL PANEL DISCUSSION—

## ROLL APPLICATION AND SERVICE SESSION— Combined Meeting with Roll Manufacturers Institute

## Ivory Room

Moderators: Harry A. Machamer, Jr., Metallurgist, Birdsboro Corp., Birdsboro, Pa.

Howard S. Orr, Project Development Engineer, Rolling Mills, United States Steel Corp., Pittsburgh, Pa.

RMI Panel: Wm. H. Betts, Staff Metallurgist, United Engineering and Foundry Co., Pittsburgh, Pa.; J. W. Luoma, Technical Assistant-Roll Sales, Blaw-Knox Co., East Chicago, Ind.; J. R. Pfouts, Superintendent Process Control, Ohio Steel Foundry Co., Lima, Ohio; E. P. Sandbach, Manager of Manufacturing, Mackintosh-Hemphill Div., E. W. Bliss Co., Pittsburgh, Pa.

AISE Panel: John F. McCarthy, Assistant Superintendent, Blooming, Hot Strip & Rolling Mills, Aliquippa Works, Jones & Laughlin Steel Corp., Aliquippa, Pa.; Clarence R. Mitchell, Divisional Superintendent—Rolling, Granite City Steel Co., Granite City, Ill.; H. E. Muller, Superintendent, Roll Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.; Arthur L. Roberts, Assistant Superintendent, Sheet & Tin Div., Bethlehem Steel Co., Sparrows Point, Md.; J. L. Walmsley, Supervisor, Stress Analysis and Testing, Research Dept., Bethlehem Steel Co., Bethlehem, Pa.

Topics:

1. Theoretical aspects of spalling.
2. Roll types, material and analysis.
3. Effect of scheduling and product mix on roll wear and spalling.
4. Effect of crowning practice on mill operation, roll wear and spalling.
5. Effect of various practices for applying cooling water on roll wear, spalling and operation.
6. Effect on the roll of rolling thin products.
7. Roll application as affected by mill operation.

## 7:30 pm—INFORMAL STAG DINNER— Gold Room

Speaker: W. M. Akin, President, Laclede Steel Co., St. Louis, Mo.

# WEDNESDAY, APRIL 26

## 8:30 am—INSPECTION TRIP—

Granite City Steel Co., Granite City, Ill. Buses leave from Sheraton-Jefferson Hotel.

# Abstracts of Technical Papers

## to be presented at technical sessions of

# AISE SPRING CONFERENCE

## April 24, 25, 26, 1961

**Sheraton-Jefferson Hotel**

**St. Louis, Mo.**

### "PHOTOELASTIC STUDY OF STRESS DISTRIBUTION IN ROLLS"

by L. MAC NAUGHTON, Roll Engineer, and A. A. BRADD, Coordinator of Rolls, Midvale-Heppenstall Co., Philadelphia, Pa.

L. MAC NAUGHTON

A. A. BRADD

△ IN recent years, there has been more and more awareness of the effects of uneven stress distribution in the roll contact area in rolling mill rolls. High stress concentrations have resulted in excessive spalling, uneven wear and other difficulties that have shortened the useful life of rolls and affected the rolled product.

This paper presents some photoelastic studies in 2-high, 3-high and 4-high mills, showing the location and relative magnitude of these stress concentrations under varying rolling conditions, and relates them to actual mill operations. Spalling of work and backup rolls can result when high concentration of stresses exceed the roll fatigue strength. The photoelastic study shows some of the causes for these highly concentrated loads, and suggests methods of reducing their magnitude.

Many rolls are loaded in service to stresses above their endurance limit. Changing the location of highly stressed areas can make it possible to prolong the length of time that a roll is in the mill between grinds, without increasing the probability that spalling will result.

### "INFLUENCE OF WEAR ON PRESSURE AND STRESS DISTRIBUTION IN ROLLS OF FOUR-HIGH MILLS"

by DR. KIN NEE TONG, Professor; M. SADRE and M. K. CHAKKO, Graduate Assistants, Department of Mechanical Engineering; and J. V. LATORRE, Research Engineer, Dept. of Chemical Engineering and Metallurgy, Syracuse University, Syracuse, N. Y.

DR. K. N. TONG

M. SADRE

△ PROCEEDING on the assumption that mechanical loading is a major factor in the spalling of work and backup rolls, a research program sponsored by the Joint Roll Research Committee of the AISE and the RMI was carried out toward two primary objectives. These were: (1) the determination of the load carrying capacities of roll materials; and (2) the determination of the stress distribution in rolls during normal rolling operations. An important consideration in this study was the effect of roll wear on this distribution.

This paper presents the results obtained in the following tasks:

1. Tension, compression and tension-compression fatigue tests

M. K. CHAKKO

J. V. LATORRE

of the shell material and the core material of a double-poured cast-iron work roll and the shell material of a cast-steel backup roll.

2. Torsional fatigue tests on the shell material of the double-poured cast-iron work roll to be correlated with the pertinent results obtained above.

3. An analytical method to determine the load distribution between the work and backup rolls having a known wear contour. The distribution of the roll separating force for several typical roll wear configurations observed in mill operations for 44, 56 and 96-in. hot finishing trains were calculated by the use of a computer.

4. Experimental and analytical examination of the validity of certain simplifying assumptions made in (3). These were found to be satisfactory.

5. Preliminary calculations of the magnitude of subsurface shear stress. Values as high as 250,000 psi were obtained in a 56-in. mill having an observed center gap of 0.040 in. due to wear; thereby indicating clearly the importance of mechanical loading on spalling phenomenon.

## "AN ANALYSIS OF THE ROLL FLATTENING OF A DOUBLE-POURED ROLL"

by DR. CARL F. ZOROWSKI, Assistant Professor, Mechanical Engineering, and DR. ALVIN S. WEINSTEIN, Assistant Professor, Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

DR. C. F ZOROWSKI

DR. A. S. WEINSTEIN

Δ A METHOD is presented for determining analytically the roll flattening due to the normal pressure distribution in the roll bite on double-poured work rolls in strip rolling. This analysis accounts for the change in the modulus of elasticity in the hard outside shell and soft inner core, but considers the materials' properties constant in each region. This method is used to investigate the roll flattening as affected by varying moduli of elasticity and the relative sizes of the core and outer shell. Comparisons are made with roll flattening predictions assuming a uniform modulus of elasticity throughout the entire roll. Conclusions are drawn with respect to the possible use of an effective or apparent modulus of elasticity to describe the roll flattening behavior of a double-poured roll.

## "THE APPLICATION OF A NON-CONTACTING MEASUREMENT SYSTEM FOR COATING WEIGHTS ON CONTINUOUS GALVANIZING LINES"

by JAMES E. REIDER, Area Manager, Industrial Nucleonics Corp., Columbus, Ohio

JAMES E. REIDER

Δ RECENT developments in the automotive industry have indicated that the producers of galvanized sheet and strip may be in a position to greatly expand their present market. Reports of the intended usage of galvanized strip and sheet in the lower components of auto body parts may result in approximately 300 lb of galvanized steel being used per unit. This would require an additional 600,000 to 750,000 tons of galvanized sheet and strip annually. This is a completely new market and would add considerable emphasis to production. It represents approximately 18 per cent of total U. S. continuous galvanizing capacity.

Although no present specifications are available on the auto market galvanized product, it is understood that this production will have much tighter tolerances and will require tightly controlled differential coating. Apparently, it will not be possible to supply a galvanized strip with excessive zinc coatings in order to insure corrosion resistance and meet minimum weight standards. Excessive zinc may affect the manufacturers ability to obtain sound welds and his specifications will undoubtedly limit maximum coating permissible. This, coupled with the fact that minimum coating weights must be completely uniform to insure corrosion resistance, imposes very definite production difficulties on the supplier.

It will be difficult, if not impossible, for the galvanized stripper sheet producer to maintain the close tolerances which may be set by the automotive industry with spot or chemical test procedures. Some form of continuous, accurate, reliable and on-the-production-line coating weight measurement system will be required to meet the industry standards of the very near future. Noncontacting radiation reflection measuring systems provide the producers with a means for meeting these new tight industry tolerances. These systems will provide the basic tool for expanding the present market by approximately 18 per cent and at the same time can afford the producer significant economic returns on their investment.

The use of this type of equipment on production lines is not new but it is very timely. This paper deals with three sections which should be of interest to galvanized strip and sheet producers:

1. Equipment.
2. Calibration, accuracy checks and reproducibility.
3. Results, both of an economic and quality nature.

The main emphasis of the paper is upon the improved quality that can be obtained through the use of this equipment and the economic results that can be realized by the user. As an example, actual installations of this equipment have shown approximately a

5 per cent savings in zinc consumption, an approximate 50 per cent reduction in scrap and an increased throughput of about 0.5 per cent by time saving on specification changes and possible line speed increases due to continuous knowledge of the coating weight being applied. There are also the intangibles of increased product uniformity and use of the equipment as engineering trouble shooting and training tool. All of these advantages add to a very significant economic return to the producer. Actual installations have shown an approximate $80,000 to $115,000 per year return to the user. This amounts to an approximate $11 to $15 per hr return from the equipment and is the basis for predicting an equipment write-off of much less than the generally accepted 12-month period.

## "OPERATIONAL RESULTS OF AUTOMATIC GAGE CONTROL ON A HOT STRIP MILL"

by THOMAS HARMON, JR., Chief Electrician; B. D. HOUSTON, Assistant Superintendent, Hot Mill, Granite City Steel Co., Granite City, Ill., and R. M. PEEPLES, Supervisory Engineer, Control Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

THOMAS HARMON, JR.

B. D. HOUSTON

R. M. PEEPLES

△ A SYSTEM of automatically controlling output gage on a 5-stand hot strip mill was put into operation at Granite City Steel Co. in the spring of 1960. The system employed two x-ray gages for feedback control. The screwdowns of all stands were equipped to be operated from either gage, and all stands were equipped with digital positioning on the screws. This was to allow the screws to be returned to a prescribed entering position after each strip.

Electrical generators and position regulators were added to existing loopers between the mills. Speed regulators were not employed, nor were existing constant potential screws altered. A production analyzer was added to the mill to print out footage of product rolled within various gage classifications.

Several extensive production runs were made on the gage system during 1960. For each period product data from the production analyzer was compiled by product classification, with the tonnage tabulated into classifications of $\pm 2\frac{1}{2}$, $\pm 5$ and over 5 per cent off set gage.

The system was modified by moving the x-ray gage from the delivery side of No. 2 stand to the delivery side of No. 1 stand. Various combinations of screw control activation were also tried, as well as various combinations of loopers.

During the latter part of 1960 the gage control was used for all production except for some special products. Usage ran from 80 to 100 per cent on a turn. This included a great variety of gage changes.

Gage improvement results proved the best where conditions were consistent. Over-all averages of the gage improvement proved to be consistent with predictions made prior to the installation. Typical gage profiles and test results are tabulated for the various conditions.

## "DEVELOPMENTS IN DRIVE SYSTEMS AND GAGE CONTROL FOR REVERSING COLD MILLS"

by K. A. PETRASKE and R. M. SILLS, Metal Rolling and Processing Engineering, Industrial Engineering Operation, General Electric Co., Schenectady, N. Y.

K. A. PETRASKE

R. M. SILLS

△ IN spite of the increasing number of tandem mills, single-stand reversing cold mills continue to have a wide field of application. These mills are today called upon to roll an ever increasing variety of metals, alloys and strip sizes with better control of acceleration, tension and gage. To meet these requirements new control components have been applied and new systems have been developed.

This paper describes installations and appraises the application of tensiometer regulators for more accurate strip tension control.

The advantages of speed regulators and motor field current regulators on the mill motor are analyzed.

Screw-down type gage controls have been used for years on many reversing mills, especially on the smaller and slower speed types. More sophisticated controls comparable to those now commonly in use on tandem mills are relatively new for reversing cold mills.

The paper describes several of these controls, and discusses the reasons for using the various systems and their advantages. The authors also discuss recent trends toward packaged power units, rectifier drives, new excitation systems and new control designs.

## "THE SENDZIMIR MILL FOR THIN TIN PLATE"

by JAMES F. FOX, Sales Manager, and A. J. BECK, Chief Engineer, Rolling Mill Div., The Waterbury Farrel Foundry & Machine Co., Div. of Textron Inc., Waterbury, Conn.

JAMES F. FOX

△ THE recent trend of the steel industry toward light tin plate has opened a new application for sendzimir mills which have so far been predominantly used for stainless, brass, low carbon sheet gages and most recently silicon steel.

It is interesting to note that the sendzimir mill had its start in the early 1930's as a mill for

A. J. BECK

rolling of low carbon steel. In its present application to tin plate, it is considered for the following applications:

1. A single-pass mill to make a further cold reduction on hard strip coming from a cold tandem mill.

2. A mill for further rolling of cold reduced and coated material.

3. A mill arranged for either single-pass or reversing operation which would operate as an addition to an existing tandem mill, and which would take on the production of the extreme variation of width and gages allowing the tandem mill to operate at peak efficiency.

One of the most important features which the sendzimir mill has to offer for the light tin plate application is its ability to adjust while rolling the shape of the mill in order to match the strip shape coming from the cold tandem mill. The crown adjustment can be made by remote control from the operator's desk. This arrangement together with the small work rolls and the usual one piece housing construction featuring uniform backing across the entire width of the strip will insure a high degree of tolerance at light tin plate gages.

During the last two years numerous tests of light tin-plate rolling have been performed on various existing sendzimir mills, on both coated and uncoated coils, but only now is our company shipping the first sendzimir mill designed specifically to produce tin plate.

This mill has $3\frac{1}{2}$-in. diameter work rolls and is of the sendzimir 1-2-3-4 cluster design. Powered by a 4000-hp mill motor and having 1200-hp winder and pay-off drives, it is set for one-way operation to roll cold reduced unannealed strip at speeds up to 3500 fpm. It is provided with a 1200-gpm coolant system with full flow filtration, a self-contained system for lubrication of the drives and complete hydraulic systems for mill screwdowns and auxiliary equipment. Conveyor coil handling systems are being furnished for the entry and discharge ends of the installation.

## "AUTOMATIC MEASUREMENT OF BAR AND STRUCTURAL LENGTHS"

by C. H. WEXLER, Associate Technologist, Instrument and Automatic Control Div., Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

C. H. WEXLER

Δ AN accurate, automatic indication of the length of the hot structural shapes immediately upon delivery from the finishing stand of a structural mill would allow hot-saw operators to cut range orders for maximum yield. This paper describes the development of a system to provide indications which are accurate to within one per cent. The system uses the rolls of the finishing stand to measure hot lengths in such a way as to minimize the effects of roll slippage and load transients. Included is a discussion of the prototype equipment installed at the South works of United States Steel Corp.

## "THE ROLLING OF ULTRA-THIN TIN PLATE"

by DR. MORRIS D. STONE, Manager, Development, United Engineering and Foundry Co., Pittsburgh, Pa.

DR. M. D. STONE

Δ THE paper considers an impending major advance in the tin plate field, the rolling and production of ultra-thin tin plate, a product ranging from 60 to 30 lb per base box (0.0062 to 0.0031 in.). The paper considers various possibilities of accomplishing the objective, with relevance to the economics involved, as the primary objective is a cheaper product, that will enable tin plate to hold its pre-eminent place in container manufacture, against the ever quickening competition of aluminum, glass and paper.

Various approaches are discussed in some detail, including: the advantages of the 6-stand tandem cold mill over the widely used 5-stand mill for rolling down to final gage; the pros and cons of a post-rolling operation in the hard state after conventional 5-stand rolling; the possibilities of rolling "double" strip as is practiced in the aluminum foil field; questions regarding rolling twice through the 5-stand with a suitably selected intermediate anneal; etc. The handling problem of this very thin product undoubtedly will bring innovations, such as the use of sleeves, common in the aluminum foil industry; or a combined continuous annealing and tempering operation, to avoid handling in the annealed state, etc. Temper rolling will require smaller work rolls.

An analysis of this subject, which pointed up reasons why a cheaper product could be produced, when it was started about a year ago, also discusses the matter of rolling a somewhat modified product that is currently being given a great deal of thought and research, a very thin but at the same time a very hard product achieved primarily by rolling. This product which has already appeared on the commercial scene at an attractively lower price, may be produced by a final cold rolling reduction of the conventionally produced coils of electrolytic tin plate, followed by a suitable cleaning and passivating operation, or by substituting a heavy cold reduction operation for the conventional temper rolling operation. The problem of product flatness will tend to become more difficult, and the use of instantaneous-crown-controlled mills is offered as an aid in this direction. It is felt that the economic production of this ultra-thin product will be achieved much sooner than is being generally prophesied.

## "FOUR-ZONE REHEATING FURNACES AND PUSHER CONTROLS"

by WILLIAM A. GREENE, Assistant Superintendent, Plant No. 2 Mills, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

Δ TWO 4-zone reheating furnaces were placed in operation during 1960 to feed Inland Steel Co.'s combination

WILLIAM A. GREENE

44-in. universal wide flange beam mill and 28-in. structural mill. This paper covers the design features and operating characteristics of the furnaces, and also describes the methods used to control the pusher stroke in the different furnaces.

The furnaces were designed to provide a heating capacity of 109 tons per hr per furnace, charging cold blooms 9-in. thick, with maximum hearth coverage. Hot blooms or beam blanks are normally charged into the furnaces directly from the blooming mill. Furnace width inside the brick is 24 ft, and furnace length measured from inside the brick at the charging end to the knuckle of the discharge slope is 72 ft. There are four heating zones: a soak zone, a top zone and two bottom zones.

A set of 16 simple gas jets located just below the soak zone burners provide a blanketing flame to maintain full temperature in the leading bloom. Metallic recuperators are mounted on top of the furnace. Maintenance of insulation on all water-cooled skids, cross pipes and jacks is considered necessary to provide fuel efficiency and evenly heated blooms.

The pusher stroke in one furnace is controlled by the pusher operator watching a television picture showing the leading bloom at the knuckle of the discharge slope inside the furnace. The pusher stroke on the other furnace is controlled by a radiation type heat detector aimed at a water-cooled slope skid pipe near the knuckle of the discharge slope. The hot bar passing into the view of the lens creates a signal which automatically stops the pusher stroke.

## "CONSTRUCTION AND MAINTENANCE OF REGENERATIVE SOAKING PITS WITH PLASTIC REFRACTORIES"

by F. E. WATERMAN, Division Superintendent, Primary Rolling Mills, and W. H. KIRWAN, Superintendent, 43-In. Blooming Mill, Youngstown District, United States Steel Corp., Youngstown, Ohio

F. E. WATERMAN

W. H. KIRWAN

Δ IN 1949 the Youngstown District primary mills of the United States Steel Corp. began to use plastic and castable refractories for various applications in the soaking pit furnaces.

This paper is presented to indicate the extent to which the plastics and castables have been used and the results which have been achieved from an operating viewpoint. With increased soaking pit availability and reduced rebuild and maintenance costs the prime objectives, monolithic linings were first installed in pit covers. On the basis of good results in that area the usage of plastics spread to other parts of the furnaces.

Certain design improvements which resulted are discussed and a new concept of soaking pit maintenance is presented. In conclusion the benefits of the over-all plastic refractory program are summarized.

## "SIMULATING THERMAL RESPONSE IN SLAB REHEATING"

by C. G. BIGELOW, Vice President, Research, Selas Corp. of America, Dresher, Pa.

C. G. BIGELOW

Δ THE critical importance of temperature uniformity in heating steel slabs has focused increasing attention upon reliable methods of determining the transient temperature distribution throughout a slab. One new tool which is proving useful in providing such thermal information is a thermal analog computer, the theory of which is described.

In the current study, the computer was used to determine the temperature distribution throughout a steel slab as it is conveyed over water-cooled rails through the heating section of a pusher-type furnace and into the soaking section where it moves over a hearth. The simulation study involved constructing an electrical model of the longitudinal section of the slab, employing electrical parameters to represent analogous thermal characteristics.

Isotherms of the longitudinal section of the slab, as it leaves the heating section, reveal a temperature gradient ranging from 1900 F above the skid rails to 2400 F at the top of the slab. This gradient is responsible for the visible shadow which develops on the face of the slab. The shadow is barely visible by the time the slab reaches the end of the holding section, which has no water-cooled rails.

Studies also were made to determine the practicability of modifying the thermal treatment in order to make the shadow disappear sooner. The most promising procedure involves soaking the slab to uniform temperature by holding the hearth temperature at a slightly higher temperature than that of the holding section, thereby supplying heat to the cooler, lower section of the slab at a faster rate than to the top.

The utility of the unit in obtaining such normally inaccessible thermal data for various related applications is discussed.

## "SUPER-LATHE FOR ROLL TURNING"

by JACK BINNS, Owner, Binns Machinery Products, Cincinnati, Ohio

JACK BINNS

Δ PRELIMINARY results of the first series of experimental turning tests with single pointed ceramic cutters are truly amazing. These tests seem to indicate that most of the apparent limitations of ceramic cutters in roll turning are really limitations effected by the machine being used.

Horsepower at the cut is the primary index of roll turning productivity. In addition it represents the relative economy of turning any given

roll. However, the true value of lathes with high capacity for hp per rpm is much more subtle. A lathe that has the ability to take high powered cuts in conventional roll material must inherently have sufficient rigidity to be able to cut rolls that are made of material normally considered not machineable. Therein lies the real economy and full value of the super-lathe. It is now possible to put into service rolls that produce the most tonnage per dressing with very little regard to their machineability. Thus, a broader and more lucrative aspect of roll-turning cost-reduction can be considered when amortizing the capital investment required for these high powered machines.

Rigidity is the most important single requirement of such a lathe, and it can only be accomplished while the machine is being designed. To attain maximum rigidity, there must be no design compromises; the proper mechanism must be put in the proper place to do that particular part of the job at hand. Each of the mechanisms must be reduced to the fewest possible parts with a minimum number of joints. When all such requirements are properly met, integrated and balanced, the results are a high rate of metal removal at increased power efficiency plus the ability to easily machine extremely hard and tough materials.

## "MODERNIZATION OF THE HOT STRIP MILL"

by JOHN H. RUSSELL, Rolling Mill Operations Engineer, Steel Div., Ford Motor Co., Dearborn, Mich.

JOHN H. RUSSELL

△ THE reasons for the "modernization and quality" program on Ford Motor Co.'s 66-in. continuous hot strip mill and the planning that went into each of the phases to accomplish the program with minimum downtime on the mill are discussed in this paper. This mill has a complete new high-pressure water descaling system on the roughing and finishing train, and a new finishing mill roll coolant and run-out table water system. The mill scale sluiceway was revamped and a new slab reheat furnace was built. The finishing mill modification was a 2-phase program requiring the ultimate in scheduling and planning in order to accomplish as much preparatory work possible prior to mill shutdown.

The shutdown phase included:

1. Complete new power supply.
2. New mill motors and drives.
3. Replacement of first two finishing stands.
4. Alteration to remaining mill stands.
5. Change in roll sizes and new bearings.
6. Replacement of mill auxiliaries, chutes, loopers and guides.
7. Run-out table modification.
8. Details on the selection of automatic gage control equipment and its performance.

A summary in this paper compares the old mill with the new and gives future plans for a detailed engineering study on the practicability of the installation of computer control for the hot strip mill.

## "ACME STEEL STANDARDIZES ON 10 SLAB SIZES FOR NEW HOT STRIP MILL"

by W. F. HINKLE, Vice President of Engineering, Riverdale Plant, Acme Steel Co., Chicago, Ill.

W. F. HINKLE

△ DURING the planning stages of replacing an old 24-in. 2-high continuous hot strip mill with an up-to-date semicontinuous mill having 4-high finishers, it was recognized that definite benefits and economic savings were possible whenever standardization could be applied to equipment, practices and materials.

Standardization of equipment results in increased interchangeability, reduced inventory of equipment and spare parts and reduced storage areas.

Standardization of practices such as speeds, drafts, temperatures, etc., improves the uniformity of product quality by reducing variables often attributable to the individual ideas of different operators.

Standardization of materials starts with standardized slab dimensions and weights. The resulting benefits would include standard coil sizes; standard weight per in. of width; fewer ingot mold sizes with reduced mold inventory; fewer slab sizes with reduced slab inventory; reduced storage areas for molds and slabs; simplified incentive rates or production standards not only on hot rolling but also on subsequent processing operations; simplified scheduling; increased flexibility in filling small orders requiring one or two slabs; and improved reheating conditions in the strip mill furnace as a result of uniform, standard slab thickness and length.

With the installation of card programming on the reversing rougher standardization provided further benefits. A greatly simplified and meaningful card numbering system was possible whereby the card number indicated the finished strip width as ordered by the customer. This provided a quick check for clerical errors and reduced the chances of selecting or using a wrong card. Also, through standardization the entire product range of the new strip mill covering widths from $7\frac{15}{16}$ to $22\frac{1}{4}$ in. in all gages from 0.050 to 0.375 in. can be produced with a "deck" of only 230 cards for the reversing rougher and by using only ten different standard slab sizes.

Some of the problems encountered in establishing the dimensions of these ten slab sizes and the ranges of finished strip widths which could be made from each size are discussed in this paper. These included studies of the spread of rectangular sections of different widths and thicknesses at various reductions; determining the maximum edge work possible on various widths and thicknesses before "buckling" or "dishing" of the bar occurred; determining and making allowances for the additional spread resulting from the varying edge bulging or "dog-boning" effect produced by different amounts of width reductions on various thicknesses and widths; and the development of an edger roll pass design which permitted heavy edge reductions without "cocking" or jumping out of the pass.

## "DESIGN CONSIDERATIONS FOR SOLID BEARINGS"

by BERNARD J. SEXAUER, Bearing Engineer, National Bearing Div., American Brake Shoe Co., St. Louis, Mo.

BERNARD J. SEXAUER

Δ THE purpose of this paper is to present to operating personnel the requirements demanded of bearings in industry, and to urge them to become even more aware of the design considerations involved to insure trouble free bearing service and long bearing life.

A discussion of desirable solid bearing characteristics and a suggested approach to selecting a suitable bearing material for specific applications are given, together with an evaluation of the functions of babbitt linings and relationship between babbitt thickness and fatigue life.

The importance of the surface finish of bearing and journal are discussed and types of finishes are recommended for full film, mixed film and boundary lubrication conditions.

## "THE DESIGN OF COOLANT SYSTEMS AS AFFECTED BY VARIOUS COLD ROLLED PRODUCTS"

by J. PHILIP WETTACH, Manager, Mill Lubrication, Engineering and Construction Dept., Dravo Corp., Pittsburgh, Pa.

J. PHILLIP WETTACH

Δ THE many varieties of products being cold rolled in the steel industry require a multiplicity of equipment and rolling solutions. The purpose of this paper is to discuss the effect this product variety has on the design of centralized circulating coolant systems. The central system must supply the proper amount of coolant to the rolls and strip and at the same time keep the lubricant in the best condition possible, free of the excess heat generated in the rolling operation.

Much attention has been given recently to the problem of rolling ultra-thin tin plate. The use of palm oil and palm oil replacements in the rolling of tin plate, due to their nature, presents a challenge to the designer of the central coolant system. Coolant systems for the rolling of tin plate are divided into two general categories, the direct application method and the recirculating solution method. The reclamation and filtration of palm oil and palm oil replacements containing fatty substances is likewise of concern to the designer of the central system.

The aluminum industry has developed several improvements in their cold rolling operations on sheet and foil, which were required in order to improve rolling methods, and to permit the high speed rolling of foil down to 0.00025 in. Even with the presence of a large amount of aluminum oxides, it has been possible to maintain mineral oil systems free of contamination above ½ micron in size, while keeping the ash content of the oil as low as 0.005 per cent. The improved filtering methods and coolant system design that has been achieved in the aluminum industry will be of interest to many in the steel industry who desire to improve surface finish and roll thinner gages.

Perhaps the most important single feature of a central coolant system regardless of the type of material being rolled is the method of filtration or clarification. This can be broken down into some general categories such as strainers, automatic edge filtration, various kinds of cartridge filters, diatomaceous earth filters, traveling cloth filtration, backwash filtration, magnetic separation, etc. This paper illustrates the most common use of the various types of filtration with respect to the material being cold rolled and the rolling solution in use.

## "RECENT DEVELOPMENTS IN WELDING TECHNIQUES FOR MILL MAINTENANCE"

by ROBERT A. WILSON, Vice President, The Lincoln Electric Co., Cleveland, Ohio

ROBERT A. WILSON

Δ THIS paper discusses improvements in techniques and developments in equipment that can be used to get the most out of a surfacing program. Specific applications are reviewed to illustrate surfacing problems as they concern rolling mill equipment and how they can be approached to obtain maximum results at lowest cost.

Maintenance hardsurfacing programs are undertaken to achieve a positive result, such as improving equipment performance, reducing frequency or duration of downtime, lowering costly replacement parts, bills, etc. Program success usually depends on simplicity with which hardsurfacing or build-up deposits can be applied and tailored to meet the service conditions encountered by the part being surfaced.

Deposit performance requirements are reviewed, such as the ability to be machined, produce a uniform wear pattern, have crack-free surface soundness, be deposited in multi-layer thicknesses and withstand extreme temperature variations. Manufacturing approaches are discussed relative to the design and development of hardsurfacing materials that can meet requirements.

Four basic types of hardsurfacing deposits; martensite, austenite, semi-austenite and carbide are compared with respect to their performance characteristics and include consideration of their ability to withstand extreme conditions of impact, abrasion, or a combination of both. In addition welding processes for producing these deposits are described.

Through illustration and presentation of case history information, welding procedures are outlined for use on a variety of applications. Welding machines developed for use with these welding processes are also described emphasizing factors of capital equipment investment, versatility and portability.

A resume includes a look to the future examining the hardsurfacing potential of the newer gas and vapor-shielded welding processes and fabricated electrode designs anticipating their effect on further improvement and expanding the use of maintenance hardsurfacing.

# Analysis of Today's Tube Welding Processes

by NORBERT C. RUBIN
Vice President*
The Yoder Co.
Cleveland, Ohio

*. . . . many welding processes are being used successfully on ferrous and nonferrous tubes. There are many factors which influence welder selections: quality of weld, inside flash, process speed, grain growth in the weld area, surface appearance, and tube size, and these factors must be considered in relation to the restrictions which the final tube use imposes . . . .*

THE development of welding processes in the field of metal tube as opposed to commercial pipe will be dealt with here. To differentiate, tube is considered to cover the range of mechanical tubing varying from furniture and bicycle tubing through all the grades of condenser and boiler tubing and including all products generally called oil country tube, such as casing and drill pipe. This article will not discuss the processes normally used to produce commercial pipe, generally known as CW or continuous butt weld.

The continuous welding of metal tube began more than 75 years ago. A very early process consisted of oxyacetylene welding but was followed rather quickly by the development of electric resistance welding. Between the years of 1920 and 1950, the development of the electric resistance welding process included the usage of higher frequencies such as 120 to 360 cycles. This era also brought about the development of d-c welding and there were some installations of arc welding for very slow speed production. The field of stainless steel tube was advanced by the advent of atomic hydrogen and, subsequently, heli-arc and argon arc welding.

However, since 1950 the development of tube welding processes has brought about a variety of systems extending into practically all fields of ferrous and nonferrous metals. Basically, the processes available to the tube welding industry today are oxyacetylene welding, submerged and inert arc welding, a-c resistance welding, d-c resistance welding, 3000 to 10,000-cycle induction welding, 450,000-cycle induction welding and 450,000-cycle resistance welding. Each of these processes is still under some stage of development but the important point is that there is a definite application for each of these methods and the question that stands before us is how to select the proper welder for a given tube production.

For the sake of brevity and to be able to discuss at greater length the most recent and more important developments, any discussion on oxyacetylene welding and submerged arc welding can be eliminated. Inert arc welding cannot be quickly by-passed because it is being used to a considerable extent in the manufacture of welded stainless steel and nonferrous tubing. While it is a relatively slow process, it can be depended upon for a steady and continuous production of high weld quality.

A-c resistance welding with frequencies ranging from 60 to 360 cycles accounts for the production of approximately 80 per cent of all welded steel tubing made in the world today. This means that the operation of such welders has become extremely simplified but more important is the fact that the resultant weld is very clearly evaluated and defined so far as the variety of tubular products is concerned. Relatively simple formulae have been established to determine the amount of volts and amps that must be fed into a welder to produce at almost any given speed.

A series of improvements has been made in a-c resistance welders over a period of years starting with the change from the stationary to the rotating transformer. This development took place mostly between 1935 and 1940, resulting in the establishment of a welder which more than doubled the production speed of previous machines. Since that time there have been numerous developments in transformer design, the most important

* At time of presentation; now Consultant, The Yoder Co.

of which centered about a controversy of water cooling vs oil cooling. Regardless of their respective merits, the fact remains that there is little difference in the basic cost of each machine, the relative production output, or the cost of operation.

However, at this moment the cooling of the transformer by the use of liquid freon is the latest stage of development. In this instance, the transformer itself is completely void of any type of tubular cooling system and, rather, it is fully sealed in a housing which is about one third full of freon. The freon merely acts as an agent to conduct the heat from the transformer to the outer housing where it is dissipated by external cooling. It now appears that because the transformer operates at much lower temperatures, and because the length of the secondary circuit is just a few in., that this development is conducive toward the use of higher frequencies, and also requires considerably less kw input. More definite data will be available on this welder in another few months.

Today a-c welders are being used to produce tubes as small as $\frac{1}{4}$-in. diameter and as large as 20-in. diameter with thicknesses ranging from 0.020 to $\frac{9}{16}$ in. The very small tubes are produced at rates of speed in the order of 150 to 200 fpm, and are used for automobile gas line and brake line tubing and refrigerator tubes. Considerable light wall conduit is produced by this method at speeds ranging between 150 and 200 fpm. There is a type of tube known as "playground tubing" which varies between $1\frac{1}{2}$ and 3-in. diameter and 0.050 to 0.093 in. thickness, and is being produced at speeds up to 300 fpm.

Boiler tubes and condenser tubes are produced by the a-c resistance welding process at speeds around 125 to 150 fpm, in thicknesses varying from 0.080 to 0.250 in.

In the large sizes of pipe, varying from $4\frac{1}{2}$ to 20-in. diameter and in thicknesses from $\frac{3}{16}$ to $\frac{9}{16}$ in., both high tensile and low tensile API line pipe are being produced, as well as oil well casing up through the J-55 grade. In this field, a-c welders up to 4400-kva capacity are being used to produce these larger diameters of pipe at speeds up to 200 fpm.

The restrictions in chemical and physical analysis of material permissible by this process are relatively few. Steels with carbon content up to 0.60 per cent have been welded satisfactorily. Probably the only other factor to be considered is that the strip must be clean, that is, at least at the portion that contacts the welding electrodes. This is normally accomplished by either pickling or shot blasting.

D-c resistance welding has been in use for a fair number of years but, because of the extremely high cost of generating equipment, its application has been limited. However, more than ten years ago the development of a combination a-c, d-c welder was worked on, meaning that 3-phase alternating current was fed to the primary side of the rotor which was comprised of a transformer and banks of rectifiers so that direct current was then conducted directly to the rotating electrodes. It has only been in the past few years that the design of rectifiers has been developed to a point where the rotor assembly in the a-c, d-c welder is small enough to be practical.

In application analysis, the d-c welder is again restricted to the welding of carbon steels. Similar to the a-c welder, it is not restricted to diameters or wall thicknesses. However, it is believed that the greatest application for this welder will be in the manufacture of tubes that require high weld quality, minimum welding flash, the utmost in inside cleanliness and optimum outside surface condition. For example, it is estimated that small sizes of refrigerator tube such as $\frac{3}{8}$-in. diameter by 0.025-in. wall can be produced at speeds up to 500 fpm with no processing required for the inside bead, and the outside of the tube being comparable to drawn tubing.

Because the d-c welder will run slightly higher in price than the a-c machine, it is not anticipated that the d-c welder will be used for tubes larger than 3 or 4-in. diameter nor walls more than about 0.156 in. The process of removing inside flash in larger tubes is relatively simple and surface condition is not as demanding a factor as it is in smaller tubes.

Approximately ten years ago new developments were made in the field of 3000 to 10,000-cycle induction welding. The prime intent of this welder was to develop a process that would produce a tube with relatively small and smooth inside flash, and enable the mill operator to use hot rolled strip without any cleaning operation before welding. Experimentation was carried on in various frequencies between 3000 and 10,000 cycles, but the majority of machines in existence today, which total between 15 and 20, are using frequencies from 4000 to 10,000 cycles.

In this machine, a water-cooled, laminated constructed inductor is mounted longitudinally above the tube, the gap being approximately 0.050 to 0.100 in.

Relatively good speeds have been obtained with this process. With a 700-kva welder, thicknesses of 0.154 in. can be welded at about 180 fpm and another of 0.065 in. will be welded at about 300 fpm. Obviously, these speeds are governed by the kva capacity of the welder but, because electrical losses are relatively high in this process, and the cost of equipment is also comparatively expensive, it is not recommended to consider kva capacities beyond approximately 1000.

One precaution that must be taken in considering the application of the 10,000-cycle induction welder is that the inductor is highly magnetic. Due to the fact that the inductor does not come in contact with the tube, it is, therefore, possible to use unpickled steel strip. However, scale which has been loosened by the forming operation tends to attach itself to the inductor through magnetic action. If this scale or other metal particles are allowed to accumulate on the inductor, a short circuit can be caused very quickly, resulting in a burned out inductor. Various devices, such as oscillating fiber glass screens between the tube and the inductor, are being used but this is still a factor to consider in the application of this welder.

There are records indicating that experiments and short production runs were made with ultra-high frequency (450,000 cycles) induction welding prior to 1940. However, this field of welding did not receive any real development until after 1950. About that time, extensive research and development was begun with 450-kc equipment and almost immediately it was found that it had excellent application in both ferrous and nonferrous metals. The induction welder in its present

stage of development consists of a multiple loop around the outside of the open tube followed immediately by a pair of squeeze rolls which bring the butt edges of the tube into contact. A voltage is induced in the tube in the vicinity of the coil, causing current to flow in a circumferential path inside the coil and then following the edges of the stock to the closing point in the squeeze rolls. Skin and proximity effects concentrate the current in the edges of the material, resulting in a high concentration of heat at the point where the two edges meet. The body of the tube remains relatively cool, which is another indication that heat is not dissipated into the tube wall but, rather, is pinpointed at the vertex of the abutting edges. The confinement of current to the surface of the metal results in welds having narrow heat affected zones, or a minimum of grain growth adjacent to the weld. This is extremely important in the welding of most nonferrous metals.

In this induction welder there is no contact whatsoever with the tube. This eliminates any possibility of surface marking or burning which might otherwise develop with electrodes. The welding method is limited to tubular applications, since the tube itself acts as the secondary of a transformer. It likewise follows that as the diameter of the tube increases, this secondary path becomes longer and the relative losses of power become greater as compared to that at the weld point. It has been found that the practical range of tube sizes applicable to this process varies from approximately ½-in. diameter by 0.015-in. thickness up to 6-in. diameter by 0.125-in. wall thickness. These dimensions will vary somewhat depending upon the type of metal being welded.

There are several of these 450-kc induction welders being built for the manufacture of stainless steel tube, containing chrome alloys up to 22 per cent. These tubes will range from approximately ¾ to 2½-in. diameter, with wall thicknesses varying from 0.020 to 0.095 in. Production speeds will vary from 50 to 200 fpm, depending upon wall thickness.

Several of these induction welders are being built for the manufacture of copper and brass tubes ranging in diameters from 1 to 3 in. and in wall thicknesses between 0.030 and 0.140 in. These tubes will be produced at speeds around 150 to 300 fpm and much of the subsequent tube will be drawn or reduced to smaller sizes of tube which, after annealing, will result in a product comparable to seamless tubing.

One of the more recent developments has been the 450-kc resistance welder. The principal difference between this welder and the previously described induction welder is that, while it also uses 450-kc current, it applies the current to the tube by means of two shoe contacts riding each of the adjacent outside surfaces of the unwelded tube. Immediately beyond the shoe contacts, the butt edges of the tube are brought together by a pair of squeeze rolls and it is at this point of contact that the welding circuit is closed, resulting in an extremely high concentration of heat. The weld quality and resultant grain structure is similar to that which occurs with the 450-kc induction weld.

The advantage of this resistance welder is that, because the current is applied to the tube by actual contact, rather than by induction, there is no limit to diameter of the tube that can be welded, and in larger diameters there are several applications where wall thicknesses of ⅜ and ½ in. are being welded. There seems to be a practical minimum diameter around ⅞ to 1 in. for this type of weld but recent developments in the method of applying current to the tube indicate that tubes as small as ⅜-in. diameter may be produced.

Generally, the 450-kc resistance welder can be used at relatively high speeds depending upon type of metal and required weld quality. For example, excellent tubes in carbon steel of approximately 0.040 and 0.062 in. are being produced around 200 to 250 fpm. Aluminum tube in the same sizes will run almost one third faster. In the larger sizes of pipe made of carbon steel, a 280-kw welder will produce ½-in. wall thickness around 40 fpm and ¼-in. wall thickness at 100 fpm or better.

At this time it is noteworthy to mention a few other recent developments in high frequency tube welding even though they are not in the specific field of ferrous or nonferrous tubes. One application is in a small diameter thin wall tube being considered by the automotive people for radiator tubing. For years this tube has been made of 0.0045 to 0.008-in. tin-coated strip formed into a lock seam tube approximately 0.060 to 0.090 in. wide by ½ to ¾ in. high. A tremendous number of these tubes are assembled vertically in the radiator core of every automobile. The development of an aluminum welded tube is being worked on although copper or brass could be used just as well for this purpose. The tube is formed in a round shape of approximately ½-in. diameter with a wall thickness between 0.006 and 0.010 in., and is then welded with the 450-kc high frequency induction weld process. After welding, the tube is reshaped to the oval or rectangular dimension required.

To date experiments indicate that speeds of 300 to 500 fpm are easily available and it appears that 1000 fpm can be reached. At these speeds cutting off becomes a problem because the required lengths are around 20 in. and must be held to very accurate tolerances.

Still another recent development or application of high frequency resistance welding in the tube field concerns spiral-weld tube and pipe. This is an old product which for many years was produced with inert arc and submerged arc welding. However, today there are already several machines in operation using the 450-kc resistance weld process. Regardless of diameter, if the tube is in the thin wall range from 0.030 to 0.109 in., greater success has been found by making a lap weld where the lap is about 1 to 1½ metal thicknesses. With this process, actual welding speeds of approximately 50 to 100 fpm have been reached depending upon thickness. The production speed of tube is then dependent upon the angle of helix, but normally the tube emerges from the welder at a rate of ½ to ⅓ of the welding speed. In the heavier walls ranging from ⅛ to ½ in., the 450-kc resistance welding process is being used to make butt weld spiral pipe at welding speeds varying from 20 to 50 fpm depending upon wall thickness, and kw capacity of the welder. In either case, thin wall or heavy wall, these speeds are eight to ten times faster than previous operations.

## SUMMARY

Probably the first statement that should be made in attempting to select a proper type of welder for a

given tube operation is that there is no panacea or single answer for the majority of tube production. In making an analysis of the tube to be produced, basic factors to be considered are:

1. Type of material.
2. Diameter and wall thickness.
3. Weld quality.
4. Required speed.

To simplify the analysis, and the selection of a proper welder, consider first the average job shop application where it is required to produce both ferrous and nonferrous tubes, of medium to good weld quality, in sizes ranging from ¾ to 3-in. diameter and thicknesses from 0.030 to 0.125 in. If the speed requirement is between 75 to 250 fpm, the general consensus dictates that the 450-kc resistance welder is probably the best suited.

In the field of strictly carbon steel tube, there are certain additional factors to be considered. In small sizes of tube below 1-in. diameter and less than approximately 0.040-in. wall thickness, which are usually in the field of automotive and refrigerator tube, inside cleanliness and minimum flash are extremely important. Today the industry has found that normal resistance welding with 360 to 480 cycles is working out quite satisfactorily although it is expected that continued development of the a-c, d-c welder will provide higher speeds and even cleaner tubes.

Still under carbon steel, there is the large range of tubes from about ¾ to 4-in. diameter, in thicknesses from 0.030 to 0.187 in. Today this covers automotive and mechanical tubes, conduit, furniture and a variety of miscellaneous tubing. It is normally produced at speeds between 100 and 200 fpm. While most of it is being made with the common a-c resistance welder at 60 to 180 cycles, there are a number of new installations using the 450-kc resistance welder. From a standpoint of initial investment, the 450-kc resistance welder is somewhat higher in price. Cost of operation is almost the same although the low frequency resistance welder does consume copper electrodes which do add a small cost factor. Probably a deciding factor in choosing between the two types of welders is in the tube manufacturer's background and experience, but the ultimate fact remains that either of the processes will produce this range of tube with equal satisfaction.

If the product is a high pressure, carbon steel boiler tube, the general consensus stands in favor of an a-c resistance welder with 180 to 360 cycles. This welding process is being used today to produce the vast majority of welded boiler tubing and it is being carried on very successfully from the standpoints of yield, weld quality and cost of operation.

Reverting to the field of thin wall conduit made of carbon steel, while most of it is being produced today by the low frequency a-c welding process, certain installations have been made using the 10,000-cycle induction welder. A few of these are operating with a high degree of success and making an excellent product, but others are experiencing a certain amount of erratic operation. It appears today that from the standpoint of not only producing proper weld quality, but also minimizing the inside flash, the recommendation leans toward 450-kc resistance welding.

In larger diameter and heavier wall carbon steel tubes ranging upward from 6-in. diameter, and varying in wall thickness from 3/16 to ½ in., the field of consideration can be narrowed to either low frequency a-c resistance welding or 450-kc resistance welding. A factor which must be considered in the selection of the welder is the acceptance of the product in the field. In spite of numerous specifications covering this size and type of tube, the manufacturer must consider his market which can be, and usually is, highly "opinionated" regarding the welding process used in the manufacture of this tube. Another very important factor in this consideration is the cost of capital equipment. At slow speeds and lower kva requirements, there is not too much difference between the cost of either type machine, but if the heavier walls are to be produced at higher speeds, ⅜ in. at 150 fpm, economy will generally dictate the installation of a low frequency a-c resistance welder.

Coming back to the field of nonferrous tube, if the project at hand involves strictly aluminum and aluminum alloy tubing, only the 450-kc induction or resistance welding should be considered. If the tube is to be used for aluminum furniture and it is essential to obtain the maximum in outside surface quality, the induction welder has the edge over the resistance welder because there is absolutely no contact with the tube at the point of welding, thereby eliminating the risk of marking the tube, however slight it might be. In other types of aluminum tube where outside surface is not so extremely important, either the induction or resistance 450-kc welder can be used with capital equipment and installation costs being approximately the same.

With brass and copper tube ranging up to about 3-in. diameter and in thickness up to 0.140 in., it appears that either the 450-kc induction or resistance welder will operate with equal satisfaction. In the world market today, there are more induction welders being used in this particular field. This is a moot question among metallurgists and operating people, but the present trend in the copper and brass trade indicates a tendency toward induction welding.

The field of stainless steel presents some quite interesting aspects in that economy plays an extremely important part. The cost of the metal is such that yield must be held at the highest level. For this reason, the great majority of welded stainless steel tube being produced today is made with the inert arc process which produces very slow speeds but a very high weld quality and yield. Even in the face of developments with ultra-high frequency welding, new equipment is being purchased today to produce stainless steel tube by the inert arc weld process. While there are several installations of 450-kc induction and resistance welders for producing chrome alloy tubes, very little of such tube is being sold on the market today. The majority of that which is being so produced is used for ornamental or decorative tubing as opposed to mechanical or pressure tubing. In this field then the choice can be made for either induction or resistance 450-kc welding, but the ultimate selection will probably be influenced by other tubular products to be produced with the same equipment.

Considerable experimentation has been carried on in the welding of still other metals such as nickel, monel, titanium, zirconium, etc. It appears that some

degree of success can be reached with either the 450-kc induction or resistance welders, but as of today no practical application or actual production has been put into effect. Nevertheless, it can be said that it is physically and practically possible to produce satisfactory welds in these metals as soon as there is sufficient demand for tubes of this nature.

In an effort to forecast the future, it can be said that the greatest concentration will lie in ultra-high frequency welding. This will probably not go beyond 450-kc because it is the maximum permissible for industrial application. There will certainly be developments made in the method of heat application but, during the next several years, this will probably involve only minor revision over equipment being produced today. While ultrasonics are being used in certain welding applications, there is no known practical application in the manufacture of tube although this may come about in the manufacture of paper-thin nonferrous metals. Probably the most pointed development foreseen today is in the over-all control of a tube mill. Either by use of metering control or punch card system, it is foreseeable that a complete tube mill and welder will be preset to to establish size of tube, speed, type of metal and weld quality without manual adjustments or manipulation of control.

## Discussion

PRESENTED BY

**E. W. ALLARDT, Plant Engineer, Babcock & Wilcox Co., Alliance, Ohio**

**N. C. RUBIN, Vice President, The Yoder Co., Cleveland, Ohio**

**E. W. Allardt:** The author remarked that if the product is high pressure carbon steel boiler tubing, the general consensus stands in favor of an a-c resistance welder with 180 or 360 cycles.

What is the basis for this consensus? Is it based on comparative experience, or is it based solely on a preponderance of use of alternating current? We are very successful in the welding of pressure tubing with 450-kc equipment.

**N. C. Rubin:** The consensus is probably due to the preponderance of existing equipment. It is not necessarily the basis of any trends that have occurred in the last year or two, but only on the basis of the volume of pressure tubing that is being produced to date. The majority is still being produced with the lower frequency a-c resistance welding. ▲

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# CURRENT AISE DISTRICT SECTION MEETING NOTICES

## BIRMINGHAM SECTION

Saturday, May 20, 1961—1:00 P.M.
Annual Stag Picnic
Lake Zamora

## BUFFALO SECTION

No May Meeting

## CANTON SECTION

Monday, May 15, 1961—Social Hour 6:00 P.M., Dinner 6:45 P.M., Inspection Trip 8:00 P.M.

Plant Visitation: Republic Steel Corp.'s New 8-In. Bar Mill, Canton, Ohio

Mergus Restaurant, Canton, Ohio

## CHICAGO SECTION

Tuesday, May 2, 1961—Inspection Trip 1:00 P.M., Social Hour 5:00 P.M., Dinner 6:00 P.M., Meeting 7:00 P.M.

Inspection Trip: Automated Structural Mill, South Works, United States Steel Corp., South Chicago, Ill. Buses leave from South Shore Country Club between 1:00 and 2:00 P.M.

Panel Discussion: "South Works Automated Structural Mill," Panel Chairman—Charles G. Hunter, General Superintendent, South Works, United States Steel Corp., South Chicago, Ill.

Dinner and Meeting, South Shore Country Club, Chicago, Ill.

## CLEVELAND SECTION

No May Meeting

## COLORADO SECTION

Tuesday, May 16, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

**"Fundamentals of Refractories,"** by Phil Johnston, Ceramic Engineer, Sales Engineering Dept., A. P. Green Fire Brick Co., Mexico, Mo.

Minnequa University Club, Pueblo, Colo.

## DETROIT SECTION

Saturday, May 6, 1961—Social Hour 7:00 P.M.
Spring Dinner Dance
Detroit Yacht Club

## LOS ANGELES SECTION

Monday, May 8, 1961
Inspection Trip: An aboard visit on the USS Yorktown Aircraft Carrier, in port at Long Beach.

## PHILADELPHIA SECTION

Saturday, May 6, 1961—Dinner 6:00 P.M., Meeting 7:00 P.M.

**"Blast Furnace Blower Selection—Axial and Centrifugal,"** by C. W. Dunn, Superintendent, Utilities, Maintenance and Utilities Div., Fairless Works, United States Steel Corp., Fairless Hills, Pa.

**"Operation of a Multiple Fuel High Pressure Boiler in an Integrated Steel Plant,"** by John W. Leming, Jr., Assistant Fuel Engineer, Bethlehem Steel Co., Bethlehem, Pa.

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

## PITTSBURGH SECTION

No May Meeting

## ST. LOUIS SECTION

Wednesday, May 31, 1961—Inspection Trip 6:00 P.M., Dinner 7:00 P.M. Meeting 8:00 P.M.

Inspection Trip: New Mill, Lewin Mathis Co., Div. Cerro de Pasco Corp., Monsanto, Ill.
Speaker, T. R. Dearden, Chief Engineer, Lewin Mathis Co.

Buffet Dinner, Plant Cafeteria

## SAN FRANCISCO SECTION

Friday, May 5, 1961

Golf Party, Mt. Diablo Country Club, Danville, Calif.

Tuesday, May 16, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Columbia-Geneva Steel Division Night

**"New Continuous Annealing Line,"** by J. M. Murphy, Works Engineer, Pittsburg Works, Columbia-Geneva Steel Div., United States Steel Corp., Pittsburg, Calif.

Spenger's Fish Grotto, 1919 Fourth St., Berkeley, Calif.

## UTAH SECTION

Monday, May 8, 1961—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

**"Steel Production Potential in Western States,"** by K. W. Mote, Exploration Analyst, Columbia-Geneva Steel Div., United States Steel Corp., Pittsburg, Calif.

Grandview Cafe, Provo, Utah

## YOUNGSTOWN SECTION

Monday, May 22, 1961—Inspection Trip 3:30 P.M.

Inspection Trip: Westinghouse Electric Corp., Transformer Div., Sharon, Pa. Assemble at plant parking lot at 3:30 P.M.

Dinner and Meeting, Shenango Inn, Sharon, Pa.

# Reduction of Maintenance Through Modern Lubricants

by J. R. WICOFF, Lubrication Engineer, The Youngstown Sheet and Tube Co., East Chicago, Ind.

*. . . . even with the advent of many widely heralded new greases, careful selection and job performance evaluation are still the most important factors in proper lubrication . . .*

STRANGE as it may seem now, grease was the first of the commercial lubricants, antedating Drake's oil well by some 14 years. While petroleum had been known for many centuries its use was largely confined to medicinal purposes. Before the advent of oil wells, petroleum was distilled from shale rock or found on the surface of water, where it had leaked out through rock fissures. The name petroleum is one coined from the Greek word, *Petros*, or *Petra*, and the Latin word *Oleum*, and means literally, rock oil. Because this oil was first found in rocks, it was supposed that rocks secreted it by their own decomposition, and was dubbed rock oil or mineral oil, and the name mineral oil is in very common usage today. Of course petroleum is not a mineral at all: it is organic. The building blocks of its construction are hydrogen and carbon, the same as animal and vegetable oils.

This first commercial grease appeared in 1845, was made with a soap of lime and tallow with petroleum crude mixed in and sold for lubricating axles of wagons and other conveyances of that day. Basically this same principle has been in use until this day in the manufacture of lubricating grease.

Grease as defined by the ASTM is, "A combination of a petroleum product, and a soap or a mixture of soaps, suitable for certain lubrication applications." Essentially it is a mixture of metallic soap and petroleum oil. This creates a mass of varying consistency and nature which can only be described as being a plastic of some kind.

Chemically a soap is any metallic salt of an acid derived from fat. Simple soaps used in grease making are animal fats in a liquid state reacted with the hydroxide of a metal. Hydroxides of a metal are also known as caustics, alkalies or bases. The hydroxide of calcium is known as quick lime, slacked lime, burned lime or just lime. The hydroxide of sodium or potassium is commonly called lye, caustic soda and caustic potash.

The common bar of soap found in the bathroom is typical of the soaps used in grease making. This bar soap is made from more highly refined animal fats or vegetable oils, and the hydroxide is sodium or potassium or a mixture of both. If one would melt this bar of soap and mix in an oil you would have a grease of some sort. If the oil chosen was a light one such as sewing machine oil, and it was mixed very well the grease would be of a butter-like nature. The more oil mixed in, the softer the grease would be. However, if it were mixed in a very heavy cylinder oil, the result would be a sticky, stringy grease. The oil as well as the soap determines the type of grease. This grease would wash out completely in water because the soap is water soluble. If the soap had been one made from calcium instead of sodium, it would not have been affected by water.

Grease making is not that simple. As a matter of fact, it is a complicated science today and a very skilled art of earlier days. It is not only the soap and the oil used, but the way that they are put together that determines the product produced. Soda soap greases are naturally fibrous and dry looking, yet they can be made short and buttery. Calcium soap greases are naturally short and buttery yet they can be made stringy and cohesive.

Many people think that a grease is valued only because of its ability to stay put, and that its use is confined to those applications where it is not practical to use oil. In other words this thinking seems to be, "If you can not use an oil, use a grease." This thinking seems to assume that, oil is a better lubricant than grease, or that its application by mechanical means is better or more dependable than with grease. Neither of these assumptions can be correct, for both oil and grease have their place in lubrication. Furthermore, it is doubtful if circulating oil systems are more dependable than the centralized grease systems of today, and certainly the grease system costs are only a fraction of that of a circulating oil system. It is hard to imagine a circulating oil system on a crane or a blast furnace, or grease lubrication of high speed pinion gears, or of steam turbine bearings.

Grease is a separate lubricant with properties all its own. Let us take a look at its physical makeup and some of its properties. The soap in grease is fibrous and these fibers form a three dimensional lattice structure, and the mineral oil is entrained between them. The absorption of oil by the soap is not like a sponge soaking up water, as the water can readily be driven out of a sponge by squeezing it. Grease retains its oil tenaciously, yet can be broken down under certain conditions. However, it seems to be the type of soap that effects the conditions of service that a grease will endure. That facility of a grease to stay together will be called simply its stability in further reference to this property.

Grease is both non-newtonian and thixotropic. Non-newtonian in that its viscosity decreases with the rate of shear increasing, and reverses with an increase in viscosity as shear rate decreases. In bearing greases

soap fibers seem to aline themselves in the direction of shear, and the resistance to this shearing action seems to be a function of the entrained petroleum oil and not of the soap. As grease eventually reaches the outer ends of a bearing its 3-dimensional lattice structure takes form again, and re-forms into its original, or very nearly original consistency thus exhibiting its thixotropic properties. Grease must attain a state of near fluidity in the direction of shear at high rates of shear. Eventually the grease will migrate outwardly to the ends of the bearings and form a ring or collar, attached to both the fixed and moving members and it is still serving there in keeping water or other contaminants from entering the bearing surface. As new grease is added, contaminants such as products of wear are forced out, not carried back to be re-entered into the bearing such as is the case in circulating oil systems.

Greases are not perfect, they give trouble like most everything else. Each grease has its limitations.

Calcium greases have long been the work horses of steel mills, and probably will continue to be for many years. These greases contain 3 to 6 per cent water as bought, and depend upon a water content to stay homogenous. If this water is lost the soap comes apart; the oil runs out and the grease decomposes. A temperature of 212 F drives out the water, but at lower temperatures the evaporation rate is rapid enough to put the maximum operating temperature at 150 to 160 F. However, these greases have great resistance to taking on more water, and are used in very wet places and where water is used as a coolant and as an assistant to lubrication. Calcium greases are usually compounded with lead naphthenate for extreme pressure characteristics, and often have blocking agents such as graphite in them for plain bearing mill service.

Soda based greases have generally good resistance to heat, a few of them have dropping points of 400 F or more. However, they are very susceptible to water, completely washing out under cascading water, and being damaged by high humidity in the atmosphere.

Many other metallic soaps have and are being made for special purpose greases. Among these are aluminum, barium, lead and zinc. Stearates and oleates of various kinds have been used either alone or in combination with other soaps. The main bulk of the greases have been calcium and sodium soap, calcium being the most used.

Much work has been done improving calcium grease. In the early 1940's a calcium acetate was marketed by a major supplier, and this was probably the first breakthrough toward an all purpose grease, which must have been the dream of all grease makers for a good many years. Of course this new grease was not an all purpose grease, but it did cover a wider range of applications than anything had before. It had a dropping point of around 400 F, good water resistance and fair stability but left a little to be desired as a thixotropic. Also, anhydrous calciums were developed in which the water was replaced with another substance, which raised the dropping point of the grease to about 260 F.

With the advent of World War II, lithium production was sponsored by the U. S. government. Since the end of the war, that metal has been available to industry at prices that make it competitive. Grease makers were quick to employ this metal in grease making. About everyone in grease making came out with a lithium grease, and they were advertised as multi-purpose. And multi-purpose they were, but not all purpose. Lithium grease has a dropping point near 400 F, excellent work stability and good water resistance. Like most greases, it does not naturally have extreme pressure properties, these have to be added.

Then another group of grease-like products have made their appearance in the past few years. They do not fit the definition laid down by the ASTM for greases in that they no not contain true soaps. They are made from colloidal sized clays, silicones or organic substances which act as jelling agents. These products are also furnished with extreme pressure additives and with molybdenum disulphide. The main forte of these greases is temperature resistance. Having no soaps their temperature limitations are that of the vaporizing point of their oils. They do not melt.

The latest and most spectacular group of the greases is the new calcium complex group with a dropping point in excess of 500 F, chemical and work stability that is amazing and fair water resistance. One of this group carries a high extreme pressure load without any apparent extreme pressure additives. Another also carries a high extreme pressure load with apparently a lead additive, but not the usual lead naphthenate. The third has no extreme pressure qualities.

To obtain special results that they do not offer naturally from greases, inhibitors and additives are added. The most common of these is lead naphthenate. This imparts a deep black color and offers resistance to welding of overstressed metal surfaces in bearings. The addition of this product often lowers the dropping point of greases 30 to 40 F. Also, in some greases it lowers the work stability appreciably, and promotes oxidation.

Rust inhibitors of various types are also used, especially in the premium grades of greases. They tend to lower the resistance of the grease to water. Water is the promoter of rust, so a grease which has little or no affinity for water cannot be expected to affect water to render it harmless. Each time an additive or inhibitor is used, some unwanted feature often turns up, and then another additive may be put in for the sole purpose of counteracting the bad effects of the first inhibitor.

A number of tests have been worked out and standardized to predict a grease's performance, and these should be studied to insure the proper application. Just saying use a lithium grease, for instance, is not very definite as lithium greases may vary widely in dropping point, water resistance, rust inhibitation, resistance to oxidation, load carrying ability and mechanical and chemical stability.

Special recommendings for special applications are not being made here, but rather a "shirt sleeve" presentation of the general makeup and characteristics of grease. It is felt that the material offered is basic information that is not generally understood, other than by lubrication people.

A number of factors should influence the choice of a lubricating grease, and the new products of the past decade certainly allow the lubrication man to make a better choice than previously. In the final analysis performance in actual service is the best indicator of what does the best job. ▲

# Orcarb Electric Furnace Process for the direct reduction of iron ore

*. . . . the direct reduction of iron ore with an average of over 80 per cent prereduction in a kiln prior to electric smelting promises flexibility and economy . . . .*

by W. R. BRADDOCK
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THE subject of direct reduction of iron ore to metal needs no introduction to the iron and steel engineer. There are at present a number of processes under different stages of development here and abroad designed to by-pass the blast furnace in the making of pig iron. Some depend on reduction of the iron oxide in a gaseous medium, such as the fluid bed reactor; while others propose the smelting of the ore to metal and slag in the electric furnace, with or without preheating or prereduction of the oxide ore. Another classification that should be mentioned are those processes which make synthetic scrap: sponge iron rather than molten metal.

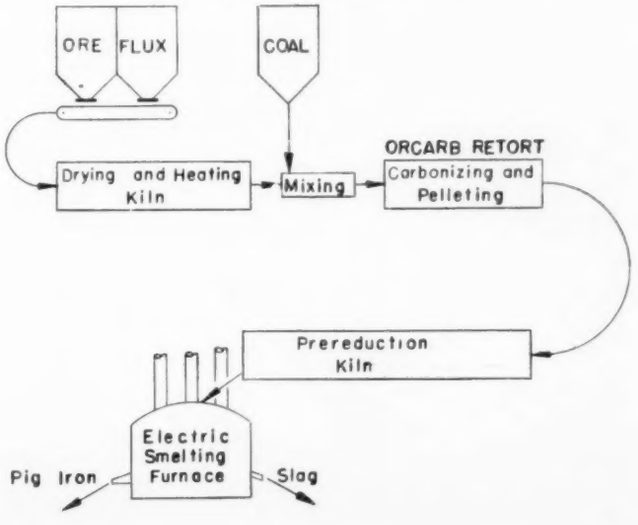
This article describes a retort electric furnace process shown in Figure 1. This process is the invention of C. E. Lesher. This process in conjunction with an electric furnace has been developed over the past year at a pilot plant. The pilot plant is located 20 miles northeast of Pittsburgh and is designed for making pig iron in the electric arc furnace.

Raw materials used in this process are identical with those going into the orthodox pig-iron blast furnace; ore, flux and coking coal. For the blast furnace, coking coals are first made into furnace coke which supplies fuel for the process and carbon for chemical reduction of the oxide ore. Flux is added to combine with gangue of the ore and ash of the coke to make a slag of desired analysis. The blast furnace must have a charge that permits passage of the furnace gases. The charge in the stack of the blast furnace must be permeable, which precludes the exclusive use of very fine sized ores. This is why fine sizes of iron ore are prepared for blast furnace smelting by agglomerating either by pelleting or sintering.

Starting with fine sized ore, dried in a kiln shown in Figure 2 and high volatile coking coal, this process prepares the charge by agglomerating the ore with low temperature coke as a binder. The retort in one continuous operation makes the coke and pelletizes the ore. If desired the flux, limestone and dolomite may be incorporated in these pellets. In the course of the work at the pilot plant during the past year, in some tests all the constituents of the furnace charge have been combined (ore, flux and carbon) in the pellets; in others the flux has been charged separately. Analysis of the pellets varies with the ore being tested. Carbon content may vary from under 20 to 25 per cent or more, depending on that required for reduction in the subsequent smelting operation.

Material from the retort shown in Figure 3 at a temperature of about 800 F is continuously charged to the reduction kiln, and from that kiln to the electric fur-

**Figure 1 — Schematic representation of this direct reduction process illustrates material flow pattern.**



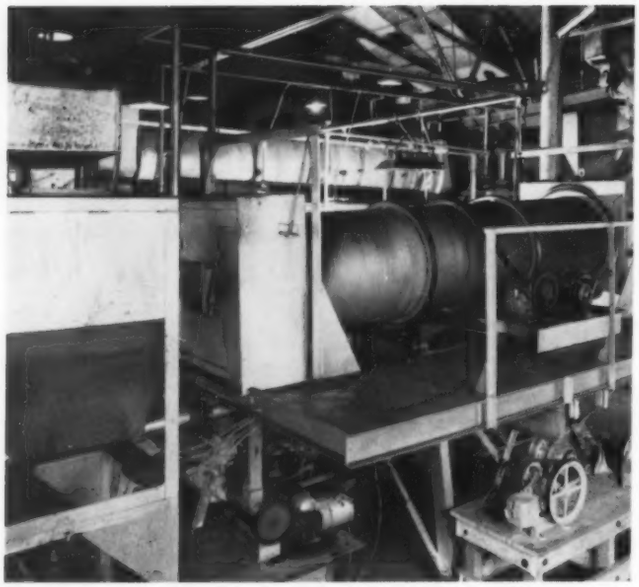


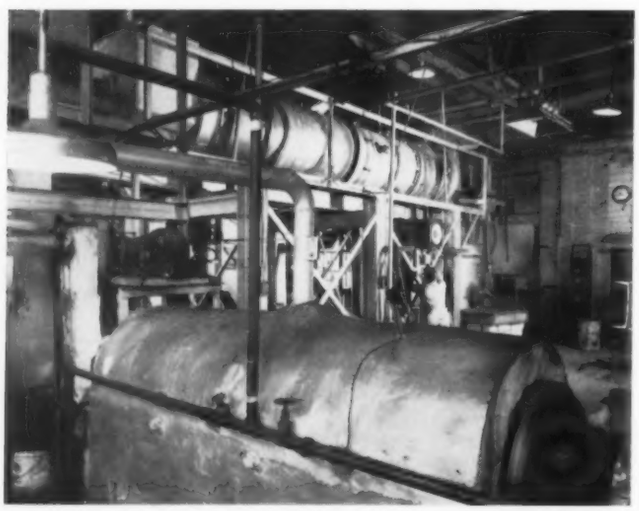
**Figure 2 — Ore is dried and can be mixed with flux in a drying kiln prior to addition of coal fines.**

nace. In the reduction kiln this material and flux are heated to about 1800 F for one to two hr and the material is then discharged into the electric furnace for final smelting.

Electric smelting without preheating or prereduction has been well developed and successfully operated abroad where power is relatively cheap and coking coal or coke correspondingly high in cost. Electric smelting has not been attempted in this country where the opposite conditions prevail. It has been established that electric furnace consumption of power, with no preheating or prereduction, is of the order of 2000 or 2500 kwhr per ton of metal.

However, with a substantial part of the chemical heat of reaction for the reduction of iron oxide provided ahead of the electric furnace, by combustion of carbon and electric furnace gases, the power consumption is reduced to less than 1000 kwhr per ton of metal. Combined with this process, electric smelting now becomes economically attractive in this country. Obviously the more oxygen removed from the oxide ahead of the furnace, the less power required to complete the smelting operation. In general terms, this sums up the advantages of preheating and substantial prereduction before final smelting in the electric furnace.

**Figure 3 — Pelletizing and carbonizing take place in a retort where the coal is transformed into coke.**



## PILOT PLANT

The pilot plant at Indianola, Pa., where the direct reduction process is being developed began operation in early 1959. The plant is fully equipped for continuous production of pig iron directly from ore and coal and has a capacity of from 100 to 150 lb of pig iron per hr.

There are three steps in the operation: preparing the agglomerates of ore, low temperature coke and flux; prereduction of the ore in the agglomerates in a rotary kiln; and smelting in the electric furnace to pig iron.

The pilot unit consists of a rotating 3 ft-0-in. I.D. x 12 ft-0-in. long direct-fired kiln in which the ore and flux are preheated to about 1100 F, followed by a mixing device in which the hot ore is proportioned with minus 4-mesh high volatile coking coal. This mixture at 600 to 700 F is fed continuously into an unlined steel retort revolving at a peripheral speed of from 80 to 90 fpm. In this retort the coal becomes plastic, picks up the ore, is rolled into pellets, hardens to low temperature coke at about 950 F and is discharged to the reduction kiln. Sensible heat in the preheated ore supplemented by indirect heating through the shell of the retort carbonizes the coal. Coking time in the retort is from 10 to 15 min.

Reduction of iron oxides, first to FeO and then to metallic iron, takes place in the rotating reduction kiln shown in Figure 4 under controlled temperatures and atmosphere in the presence of carbon. Superheated gas from the furnace and combustion of the CO developed in the kiln supply the necessary heat for the reduction reactions. In the rotary kiln the iron oxides in the bed are heated to about 1800 F for an hr or more. A recent test of more than a week of continuous operation gave an average reduction in the kiln of more than 80 per cent.

The reduction kiln is 2.5-ft I.D. x 20 ft-0-in. long with a 6-in. refractory lining. Provision is made for sampling kiln gases and material in progress at points along the length of the kiln. Temperatures at several points are recorded. Retention may be varied from 1½ to 3 hr. With maximum temperatures of 1800 to 1850 F there has been no ringing or build up of the reduced charge material.

The prereduced material flows into the electric furnace shown in Figure 5 through a connection in the roof, through which the gases from the furnace flow countercurrent into the kiln. The furnace hearth is 2.5-ft I.D., or about five sq ft and has three 4-in. graphite electrodes in triangular position. Operation is normally at 60 to 70 volts.

Ore used in the tests made thus far have been concentrates, both magnetite and hematite, and both very fine, largely less than 325-mesh size. Pittsburgh bed high volatile coking coal with limestone and dolomite in fine sizes have been obtained locally.

Basic pig iron has been the principal product with variations in silicon up to seven per cent and carbon of less than two per cent. The metallurgy is quite similar to that of the pig iron blast furnace; however, with

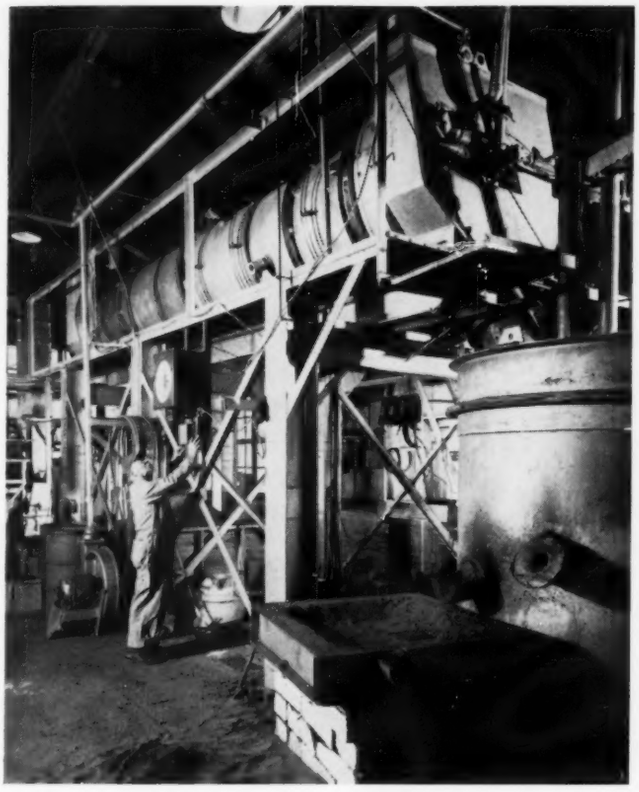


**Figure 4 — Material from the reduction kiln is charged into the electric furnace through an opening in its top.**

**Figure 5 — Approximately 100 to 150 lb of pig iron per hr are tapped from the pilot-plant electric furnace.**

greater ease of control because of the lesser time lag between burden and hearth temperature changes and tap.

Electric furnace smelting of iron ores with prereduction, whether in rotary kilns or otherwise has yet to be demonstrated on a commercial scale, but it is rapidly developing as its inherent advantages are becoming appreciated. It is established that the capital cost of the plant is half that for coke ovens, sintering or pelleting plant and blast furnace. This promises a more rapid return of investment. Greater flexibility is offered not only because the operation may be idled and started up at will, but because the two operations, reduction and smelting, are separately controlled as to time and temperatures. As presently conceived in increments of hundreds of tons of product per day, the process offers a wide range in capacity, for the smaller user as well as the large-scale producer. The electric furnace process for 500 tons per day may be as economical as for two or four times that much, which quite obviously is not true of the coke ovens, blast furnace route.

In the development this process of agglomerating the ore and making the coke offers several notable advantages. Outstanding is its adaptability to extremely fine size ores and concentrates, see Figure 6. Dusts too fine for handling by sintering or pelleting are being agglomerated in this retort. Coupled with this feature is the ease with which high prereduction is attained in the rotary kiln. Whereas others with simple mechanical mixtures of ore and low volatile carbonaceous charge material, or with pellets incorporating carbon, appear to consider 50 to perhaps 60 per cent as the economically attainable prereduction 80 per cent has been achieved here on an economical basis. Success is attributed to the intimate association of reactive carbon with the fine sized oxide ore. The more reduction in the kiln, the less to be done by electric power in the furnace thus less cost per ton of pig iron.

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**Figure 6 — The raw materials used in the process, the ensuing pellets and the final product are shown, illustrating the fine sized ore and coal which are used in this process.**

**Figure 1 — An aerial view of the Dominion Foundries and Steel, Ltd. plant shows the extent of its growth over the past ten years.**

# What's New at DOFASCO

*....a continuing program of mechanization and improvement is necessary to maintain production, reduce costs and satisfy steel customers....*

by D. O. DAVIS,
Vice President, Engineering
Dominion Foundries and Steel, Ltd.
Hamilton, Ontario, Canada

DOMINION Foundries and Steel, Ltd. has grown from a steel foundry with a 600-ton yearly capacity employing less than 150 men, to a completely integrated steel plant employing in excess of 4000 men, and from a site covering five acres, to one covering more than 300 acres (Figure 1) which is quite a change since the plant was founded in 1912 by the late Clifton W. Sherman.

In 1920 looking for diversification, a universal plate mill was installed, and then in 1935 a 20-in. cold reducing mill was installed: it was on this 20-in. mill that the first tin plate in Canada was produced. The demand for tin plate and other cold strip products continued to increase, necessitating the installation of three additional cold reduction mills along with other necessary process equipment.

The next 10-year expansion period included: electric steelmaking furnaces; the No. 1 continuous annealer; a 2-stand temper mill and the No. 1 electrolytic tinning line. Because of an ever increasing demand for steel

**Figure 2 — Construction of the No. 3 blast furnace was completed in record time.**

and a diminishing supply of scrap, the first blast furnace was built in 1951 along with coke ovens and other auxiliary equipment to make the company a fully-integrated steel producer.

Dofasco has an interesting growth pattern, from a capacity of 250,000 ingot tons in 1949 to 1,000,000 tons in 1959. A $100,000,000 expenditure in plant expansion and improvements included the installation of a new 4-high hot rolling mill, oxygen steelmaking furnaces (the first on the continent), the No. 1 56-in. cold mill, the No. 1 continuous galvanizing line, the No. 2 electrolytic tinning line, the No. 2 continuous annealer, a second blast furnace and a new 2-high hot roughing mill.

The expansion program completed in 1959 included: three continuous stands in the hot mill; the No. 2 black pickle line; the No. 2 56-in. cold mill and a cold rolled sheet dept. The current expansion program consists of: the No. 3 blast furnace; enlarged oxygen steelmaking facilities; additional soaking pits and the No. 2 continuous galvanizing line.

## THE NO. 3. BLAST FURNACE

The No. 1 blast furnace was built in 11 months, the No. 2 furnace in ten months, and the No. 3 furnace was scheduled for completion in eight months. To meet the schedule on the No. 3 furnace shown under construction in Figure 2 a departure from the usual methods of construction was necessary. Because the carpenters in the Hamilton district were on strike for 90 days, practically all construction was at a standstill. But it is the rule of Dofasco as well as the rule of the theater that the show must go on. Other possible methods of going ahead with the blast furnace foundations without using wood and nails were studied.

Although the basic idea of using concrete block for forms was soon conceived, it took ingenuity to make it a success. It is interesting to note that the over-all result was a considerable improvement over conventional methods of forming. From January 15 to 31,

**Figure 3 — Concrete block forms were used and proved to be economical and time saving.**

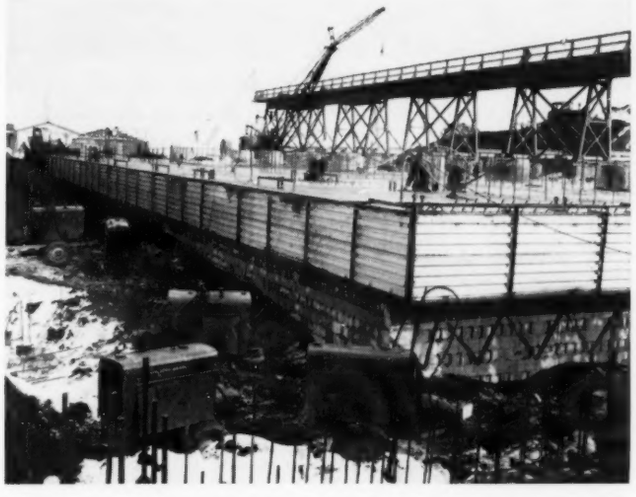


**Figure 4 — Sheeting was used as side wall forms, and required no external supports.**

**Figure 5 — The stoves and furnace were erected using large prefabricated sections.**

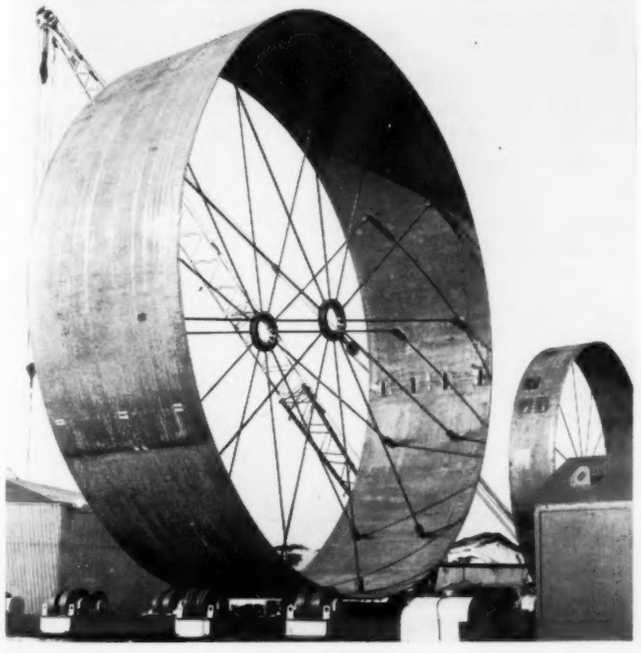


**Figure 6 — Erection of the prefabricated sections of the three stoves was faster than normal erection methods.**

**Figure 7 — Steel erection progressed at a fast rate through the first 50 days.**

1960, the foundations for the furnace proper and the stoves were formed with concrete block and 6000 cu yd of concrete were poured in that 16-day period. The No. 2 furnace required six weeks for the same job. Figure 3 shows the concrete bottom pad for the stoves and erection of the outside concrete block ring wall for the furnace proper.

In Figure 4 note that the sheeting used as side wall forms for the main top slab of the stoves, was tied back into the reinforcing steel thus requiring no external supports for the forms.

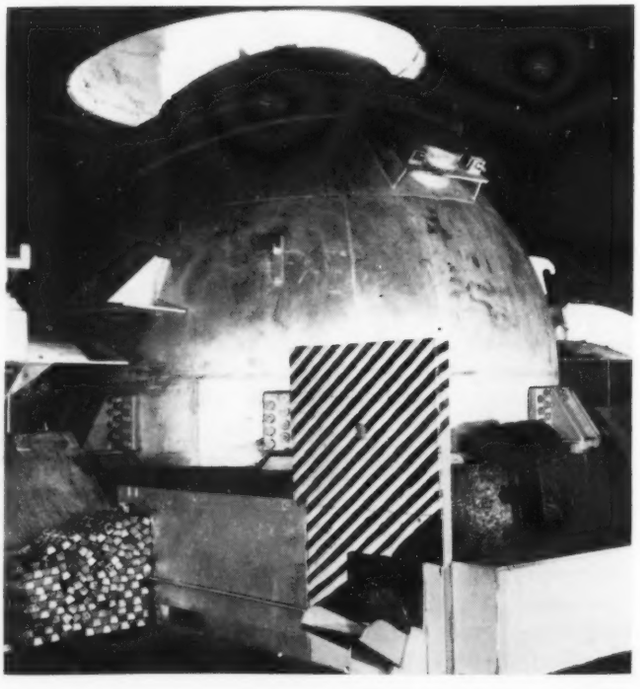
The reinforcing steelmen told me that they could place steel twice as fast in block forms compared to wood forms because of there being no obstructions in the block forms.

Erection of the steel shells for the blast furnace and stoves is usually done by field welding individually rolled and formed plates into the finished structure. To reduce both the time factor and the costly fieldwork involved, it was decided to set up a fabricating shop

**Figure 8 — Cooperation with a chemical company permits utilization of excess coke-oven and blast furnace gas.**

**Figure 9 — Synthesis of urea and all related processes are controlled from a central room.**

**Figure 10 — Oxygen converters were installed to increase Dofasco's steelmaking capacity.**



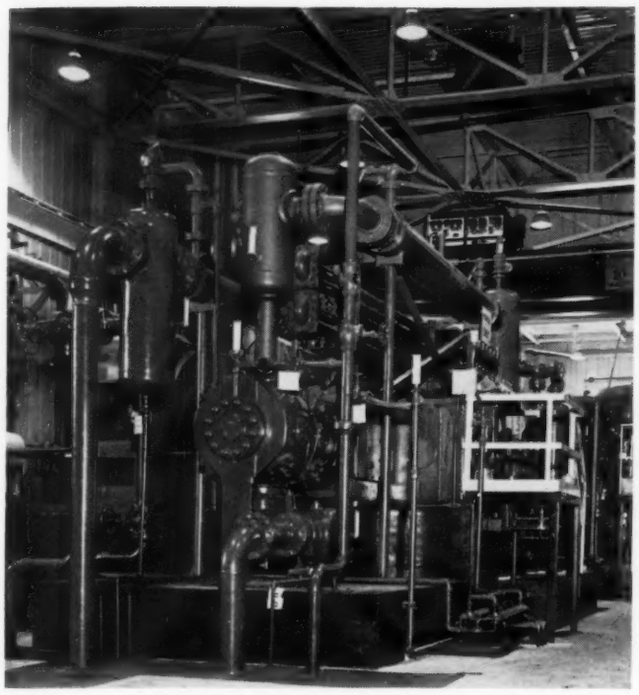


**Figure 11 — Compression of liquid oxygen requires a relatively simple compressor.**

(Figure 5) on the furnace site and erect large prefabricated sections of the furnace and stoves. Rapid progress was possible using this method. In Figure 5 a stove shell section 26 ft in diameter and made up of 96-in. wide plates, ¾-in. thick, five plates per ring, is being assembled.

Figure 6 shows the three stoves in erection progress. On the No. 2 furnace 105 days were required to erect the three stoves; whereas, on the No. 3 furnace in spite of the fact that the stoves are considerably larger, they were erected in 25 days.

The bottom section of the furnace stack was welded in the prefabrication area, ready to be erected on the mantle. The tuyère jacket also was prefabricated. Figure 7 shows the stoves, high-line, furnace, etc., 56 days after the start of steel erection, or approximately 40 working days.

## TIGHT INSTALLATION SCHEDULES

A significant part of the familiar and necessary process of making equipment pay for itself, in as short a time as possible, is the tight installation schedule. Here again the engineer can play an important role. Once management has made a decision to install a new unit, the sooner it is in production, the sooner the profits start coming in.

Is it just a habit on the part of Dofasco, for example, to set installation schedules which are 60 to 70 per cent of the time set by the industry as a whole? Are these tight schedules set up to make life miserable for construction engineers, equipment builders and others? The company is in business for just one reason, to make money, and money is made by selling goods at a profit and at a time set by the market. With respect to the part that construction plays in profit-making, building must be done as quickly as possible, for as low a cost as possible and with as high a quality of installation as possible.

Tight installation schedules being met accomplish two major objectives:

1. Money invested is working sooner and thereby making more money to build more plants.
2. New equipment is installed so that steel products can be supplied to customers as and when they are needed.

## CYANAMID

The steel industry is today producing more coke-oven gas than they as an industry can use and coupled with the greater distribution of natural gas by pipe lines, this results in considerable coke-oven and blast furnace gas being bled daily.

The assignment is to make use of this excess gas other than as a fuel. Dofasco participates in such a program with a Canadian chemical company. Their plant is located alongside our blast furnaces and coke ovens, and is shown in Figures 8 and 9.

Coke gas is delivered to this plant, stripped of its hydrogen, and the balance of the gas returned for use in soaking pits, annealing furnaces, etc.

At the same time the nitrogen from our oxygen plant is delivered to this plant and combined with the hydrogen to produce liquid anhydrous ammonia.

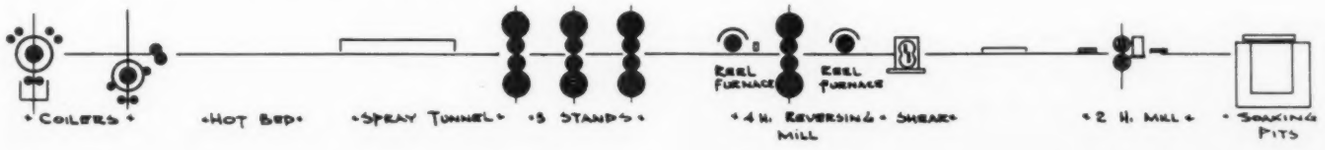
Carbon dioxide is then removed from the blast furnace gas and united with the anhydrous ammonia to produce a product called urea, a crystal. Urea is today termed one of our base chemicals, being used in both the fertilizer and plastic fields. It might be of interest to comment that, in Japan a pilot plant is now operating which produces nylon from urea. To the best of our knowledge, this is the first such plant.

## OXYGEN PLANT

As ingot production increased, additional steelmaking capacity was required, and management took a long hard look at the modern open hearth shop: a sound and proved practice, but one requiring a high capital investment. To reduce the cost and make money available for other expansion, it was decided to install oxygen steelmaking equipment, the first plant of its kind in the American continent, a furnace of which is shown in operation in Figure 10.

The capital cost of the plant was one half the cost of

**Figure 12 — A schematic of the hot mill equipment illustrates the unusual installation.**



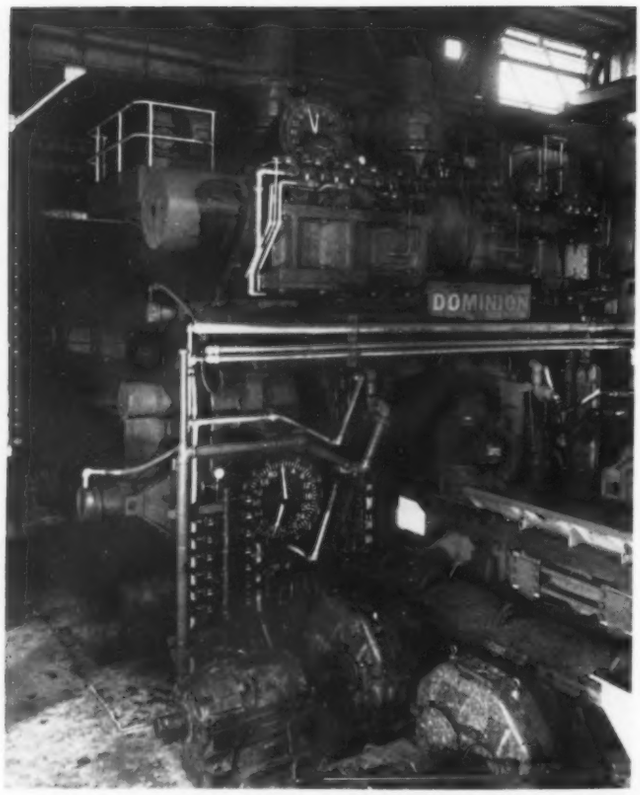



**Figure 13 — A new 2-high universal mill was installed to replace an outmoded mill.**

a comparable open hearth installation, and the success of the process is best judged by the rapid increase in oxygen steelmaking installations in the U. S. and Canada.

The modern oxygen steelmaking practice was made possible only by the production of low cost, high purity oxygen in commercial quantity. There are three tonnage oxygen plants at Dofasco, the No. 1 and the No. 2 gaseous process plants, each with a capacity of 100 tons per day of 99.5 per cent of pure oxygen, and the No. 3 plant which is a liquid process plant with a capacity of 150 tons per day.

The liquid process plant has several advantages over the gaseous plant, for the liquid process continuously flushes out all impurities in the liquefied air being processed. However, the gaseous system "boils off" oxygen from a continuously fed pool of liquid air which concentrates impurities in the system. A further advantage of the liquid process is that liquid oxygen is compressed by a simple pump (Figure 11) and raised to process pressure by gasification; while the gaseous process delivers low pressure oxygen which necessitates the use of a very costly nonlubricated, low-speed, multistage compressor to attain process pressure.

## HOT ROLLING DIVISION

The rapid expansion of the last decade made it necessary to replace the entire hot mill installation, starting in 1954 with a new 4-high reversing mill and coiler. Figure 12 shows the complete hot mill installation. In 1957 a new 2-high roughing mill with attached edger was installed, along with new approach and runout tables. In 1959 three continuous stands were added to the reversing 4-high mill, and a new 2-roll downcoiler was installed. The mill as it now stands is a unique and versatile installation.

Figure 13 shows the new universal type 2-high mill which was installed in 1957, in the same location as the original mill. When the three continuous stands (Figure 14) were added to the hot mill, the existing 4-high reversing mill was widened from 60 to 66 in. during the continuous stand installation shutdown. This modification completed the program for production of 60-in. wide hot strip, a new Canadian product.

Installation of the three stands, along with the new coiler and additional runout tables, was carried on while the mill was in production. Total downtime required was ten days over three separate shutdown periods. The 2-roll downcoiler is a new design and has proved satisfactory. A coil handling conveyor system at the coiler discharge upends the coils prior to storage. The storage of a sufficient inventory of hot strip coils has long been a problem not fully solved by expensive overcrowded coil storage buildings. Palletized coil storage and Ross straddle type carriers to move the pallets seem to be an answer.

To market 60-in. hot strip a cut-to-length line (Figure 15) was installed, along with the hot mill

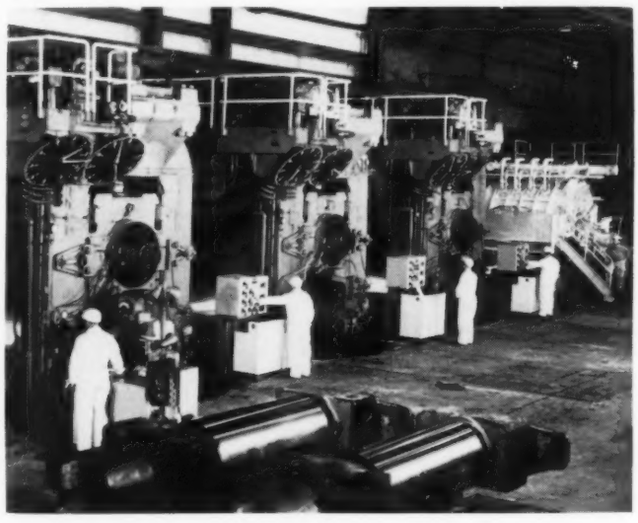
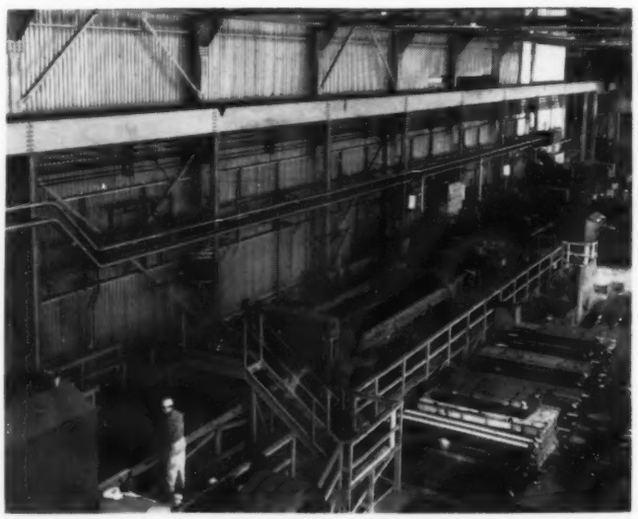


**Figure 14 — A 66-in. wide, 3-stand hot mill was installed to permit production of 60-in. hot strip.**

**Figure 15 — Hot rolled strip is cut to lengths ordered by the customer.**



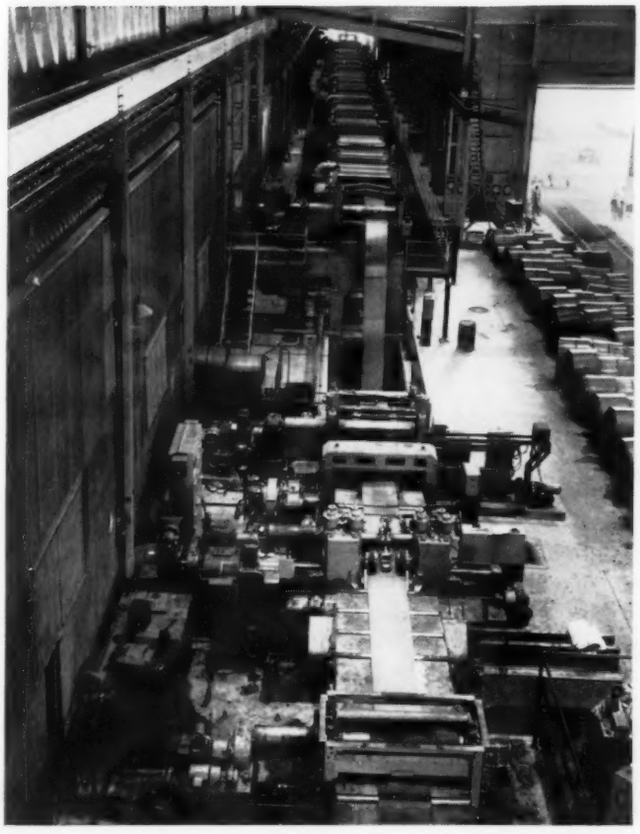


**Figure 16 — The production of wider strip necessitated the installation of the No. 2 black pickle line.**

continuous stands, the mechanical equipment for which was all built in Canada.

### THE NO. 2 BLACK PICKLE LINE

Additional pickle line capacity was required, both for increased production and also to process 60-in. product for this new strip market. Figure 16 is an over-all view of the No. 2 black pickle line. A unique feature of the line is the entry end processor which controls the deep bending scalebreaker roll to give uniform cold working of merchant hot strip.

### THE NO. 2 56-IN. COLD REDUCTION MILL

The No. 2 56-in. cold reduction mill (Figure 17) is both unusual and interesting. Provision is made to drive either the work rolls or backup rolls, with a separate motor on each driven roll. The work rolls range in size from 10 to 16½-in. diameter and 3000 fpm is the top strip speed. A total of 4340 hp is provided on the mill roll drive with 2170 hp provided on each reel.

### COILING TIN PLATE

Some time ago several of the tin-plate customers indicated that they were going to install machinery in their operations which would handle coiled tin plate. Figure 18 shows tin plate being coiled at the delivery end of the No. 2 electrolytic line. Such coils afford the customer the advantage of stocking the tin plate by width, gage and coating alone, for when stocking sheets, the length had to be taken into consideration.

In late 1959 the machinery was installed at the exit end of the No. 2 electrolytic tinning line, and coils of tin plate up to 19,000 lb are now being shipped.

The installation of this coiling equipment has cost more than $1,000,000, but it is a step to keep well established in the market and equipped with the very latest type of machinery. It is interesting to note the manner in which the tin-plate sheet classifier and piler are by-passed, see Figure 19. In spite of the opinion of many of the experts that this 106-ft jump could not successfully be done, the line is in operation.

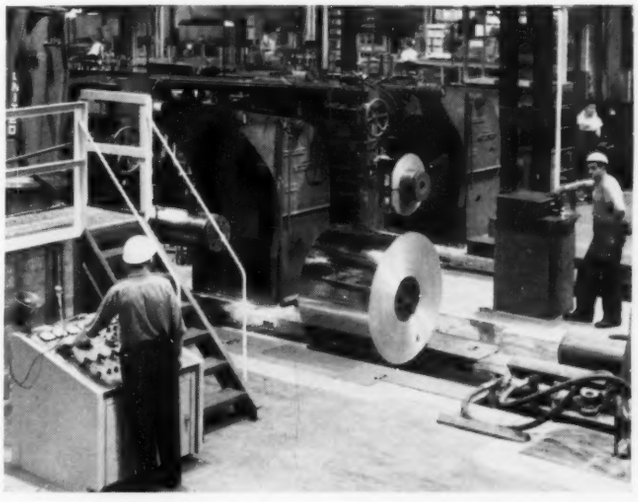
### GALVANIZING DIVISION

In the U. S. and Canada, the market for continuous galvanized sheet and strip has grown at a tremendous rate. This rate can be attributed to both the high quality of the continuous product and new uses. Although the No. 1 galvanizing line for 48-in. wide product was just put into operation in 1955, we shall have the No. 2 line for 60-in. product in operation shortly. Provision is being made on the No. 2 galvanizing line to aluminize.

A new and interesting product now out for test by some of our customers is fully galvanized on one side, and satincoat, a paintable surface, on the other side.

**Figure 17 — Separate motor drives are arranged to permit driving of either the backup or work rolls.**

**Figure 18 — Electrolytic tin plate is produced in coils weighing up to 9½ tons.**



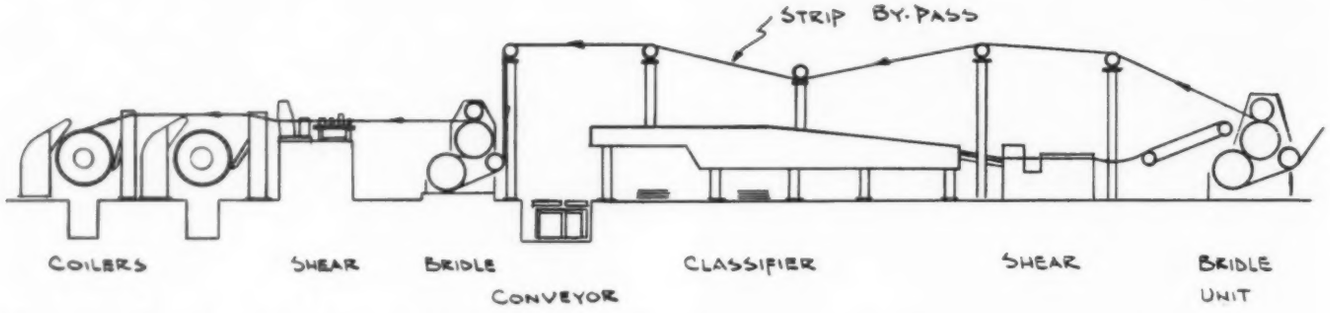



**Figure 19 — Production of tin-plate coils requires by-passing of the shearing, classifying and piling equipment.**

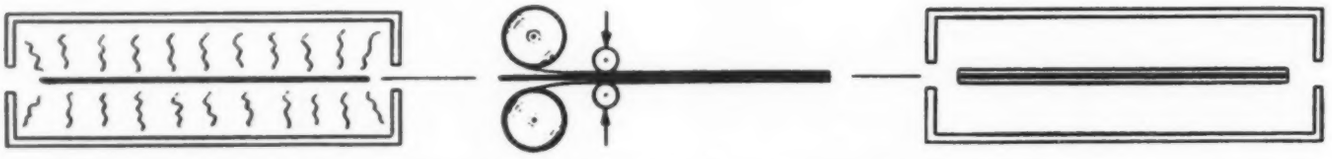


**Figure 20 — The schematic diagram illustrates an asbestos-coated sheet process developed at Dofasco.**

*Asbestos coating*—A new product in the galvanizing field (Figure 20) is an asbestos coated galvanized sheet: its application at present is for culvert stock. It is made by first heating galvanized sheets until the heavy zinc coating reaches a plastic state. Then asbestos in the form of thin sheets are applied to both top and bottom of the galvanized sheet and pressure rolls embed them securely in the softened zinc coating. The sheet then is grayish in color with a fuzzy surface. Finally the sheet passes through an asphalt impregnating unit, and the asbestos fibers key the asphalt tightly to the zinc coating.

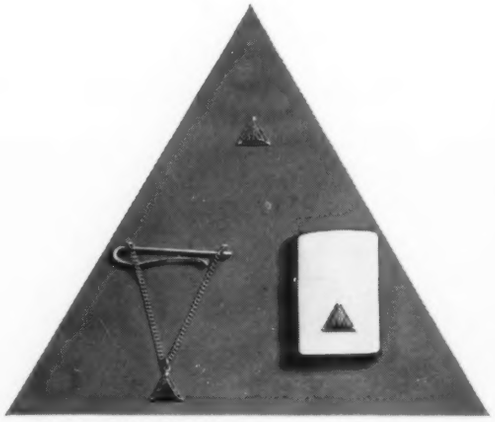
## SUMMARY

Dofasco has many things to be thankful for:

1. Very fine customers, who are the basic reason for our success.
2. Most pleasant relations with competitors in the Canadian steel industry.
3. A very capable group of electrical and mechanical equipment builders in Canada, who are doing a job second to none.
4. Our good steel neighbors to the south, who are always willing to help us. ▲


# AISE Accessories Available To Members

- MEMBERSHIP PIN—complete with plastic case, finished in handsome blue and gold— $2.00
- TIE CLASP—gold plated tie bar and matching chain with AISE insignia, in attractive plastic case— $5.00
- LIGHTER—famous-make Zippo, in brush finish stainless case with embossed AISE insignia— $6.00



**ASSOCIATION OF IRON AND STEEL ENGINEERS**

**1010 Empire Building** **Pittsburgh 22, Pa.**

# Republic Steel Corp.'s 13-Ft Wire Mesh Facilities at Gadsden

by C. J. KINSEY
Assistant Chief Engineer
Republic Steel Corp.
Gadsden, Ala.

*. . . . ingenious design and careful manufacture have produced a continuous wire mesh welder to operate at speeds up to 100 fpm . . . .*

THE continuous welder was virtually unknown outside Republic Steel Corp. until the advent of our 13 ft-0-in. welder. Until this time there were at Gadsden the only two continuous welding machines in the country.

One of these machines is a 9 ft-6-in. welder built in the 1920's in Youngstown and moved to Gadsden in 1938. This machine was set up on 6-in. longitudinal wire spacings and never changed. The width and cross wire gage has varied.

The other machine makes mesh up to 6 ft-2-in. wide and can make mesh of any standard gage and wire spacings in this range. These two machines operate at a fixed rate of speed. The 9 ft-6-in. machine operates at 55 fpm at 72 per cent efficiency while the 6 ft-2-in. machine runs at 47 fpm at 71 per cent efficiency.

When it was announced that the Federal Government would start a highway program, the two existing machines were too narrow to make mesh to government highway specifications. After due investigation it was decided to build a new machine wide enough to meet these specifications.

Several things were to be taken into consideration before starting to design or build such a machine. Any new machine should have the fastest top speed possible and cover as wide a range as possible. Also, after the machine was designed who could build it? Since time to get the machine into production was short and time required for outside manufacture was so long, it was decided to do the work in our own shops.

This, too, posed a problem. Could the maintenance shop build a high production machine with some parts as intricate as a sewing machine and continue to perform properly its primary function of keeping the mills in operation? Since 79 longitudinal wires were to be used in the new machine, there were several instances which required that as many as 79 duplicated parts were to be made. The shop had to make several jigs and fixtures to assure duplication to as close a tolerance as possible.

**Figure 1 — Equalization of tension in the wires is achieved by passing the lighter gage wires once around the drum.**

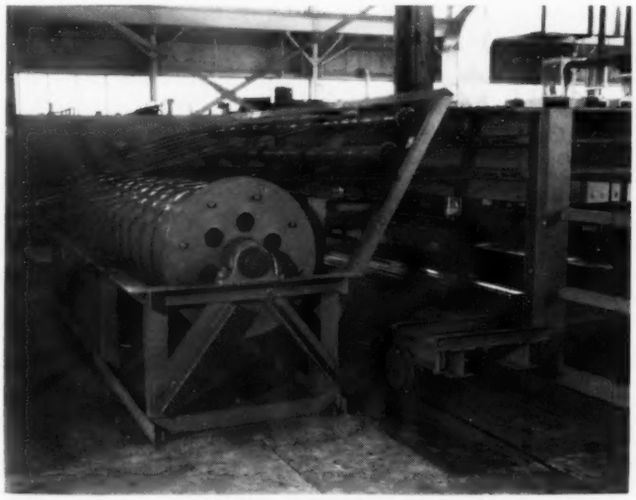


**Figure 2 — Cross wires are loaded into magazines which feed from the bottom.**

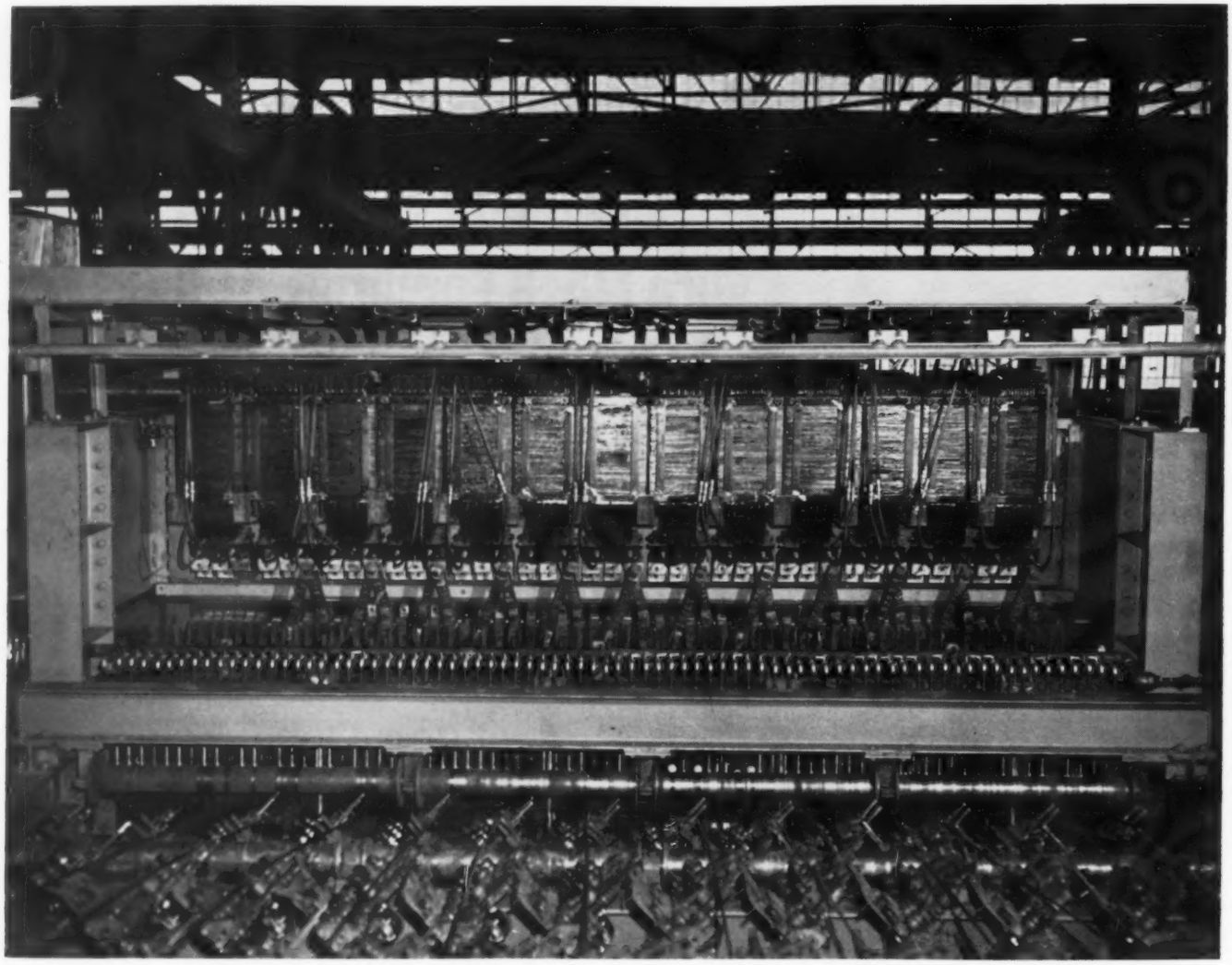


**Figure 3 — Wire passes from the straighteners, underneath a deflector roll, and through the welder.**

This added to the cost, but the finished machine was comparable to any machine on the market.

There is a transverse wire storage area composed of 80 "high hat" type reels. The maximum number of reels needed is 79, which will produce wire mesh 13 ft-0-in. wide on 2-in. centers. Wire can be stacked on the reels by an overhead tramrail crane system or the reels can be transferred from the wire mill to the mesh machine storage area fully loaded and ready for use. If the reels are loaded on site, 200-lb coils are used. If they are loaded at the wire mill 5000-lb coils are anticipated.

A tight wire safety device follows the storage and feed area. This device stops the welding line when a tangle occurs or if one of the reels fail to uncoil. When this happens the tight wire will raise a block which trips a limit switch, shutting down the entire line.

Next there is an equalizing drum. When running the smaller gages of wire mesh the longitudinal wires must be wrapped once around the equalizing drum. This is done to equalize the pull from the welder back to the reels so that one wire does not have more tension than the others. In the larger wires this is not necessary. At this point the wires are also separated to the proper elevation to enter the straighteners.

In Figure 1 is shown the equalizing drum and the overarm separators. The wire can be seen entering the pipe guides which guide the wire into the straighteners. Underneath can be seen the cross wire buggy which is used to carry the cross wires to the magazines.

Figure 2 shows one of the four magazines. The cross wires are fed into the magazine and at the botton can be seen the drive shaft that strips the wires from the magazine.

The cross wire feed magazine drops the cross wires on the conveyor which runs underneath. This is done by loading a vertical magazine's leg with cross wires precut and straightened by one of four straight and cut machines adjacent to the magazines. There is a series of slotted rotating disks that strip the wire from the magazine leg. The depth of the slots is varied according to the gage of wire to be run. The disks are designed to strip the wire and deposit it on the conveyor on the desired centers.

There are four magazines, No. 1 and No. 2 magazine drop on 6 and 12-in. centers, No. 3 and No. 4 magazines drop on 4 and 8-in. centers. Any standard cross wire spacing from two through 16 in. can be obtained by one of the magazines, or by two magazines alternately depositing the wires onto the conveyor. Two-inch spacings can be obtained by No. 3 and No. 4 magazines set on 4-in. centers dropping alternately and 3-in.

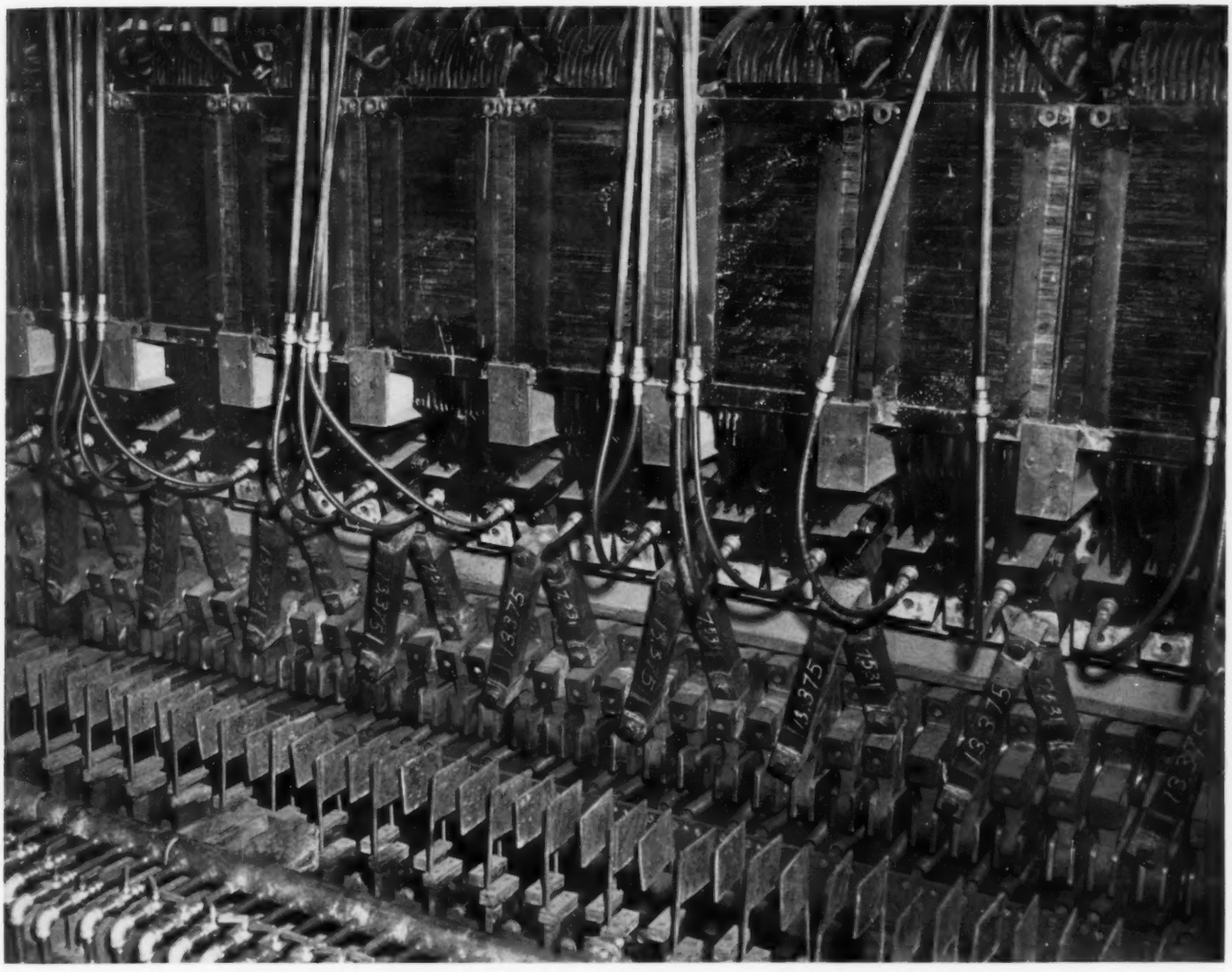


**Figure 4 — A wire break detecting device stops the machine should any longitudinal feed wire break.**

spacings by two 6-in. magazines dropping alternately; 4-in. spacings by No. 3 or No. 4 magazine; 6-in. spacings by No. 1 or No. 2 magazines; 8-in. spacings by No. 3 or No. 4 magazine; 12-in. spacings by No. 1 or No. 2 magazine; 16-in. spacings are obtained by No. 3 magazine only. An interrupter has been designed to rotate 1½ revolutions to one revolution of the magazine. When set on 8-in. centers the interrupter will block every other 8-in. slot to deposit the wires on 16-in. centers.

The cross wire feed conveyor carries the cross wires from the magazine to the welding drum. The feed conveyor is a 1-in. pitch chain with a special lug on every other link (2-in. centers) to carry the cross wires. This conveyor delivers the wire to a transfer chain that carries the wire over the welding drum to be welded to the longitudinal wire. A ½-in. pitch chain is used here with a special lug every 2 in. except when running 3-in. centers. Then a transfer chain with special lugs on 3-in. centers must be used.

Figure 3 is a view taken from the straighteners looking into the entry side of welder. Here we see the bank of 13 transformers. When this figure was made the machine was set to make mesh 12 ft-0 in. wide with transverse wires set on 6-in. centers. In the lower section of the picture can be seen the straighteners.

Figure 4 is a close up view of the transformers and lead connections. The series of flags are on rolls which ride on the longitudinal wires. If one of the wires breaks this lets a flag drop into the path of a signal light, blocking the beam, cutting the machine off until the wire can be patched. If no wire passes under a signal flag, the flag can be locked into the up position.

Figure 5 is a view across the operators side of the welder (opposite to the transformers). The operators controls can be seen on the column. The meter at the top is the speed indicator. The speed of the machine is 0 to 100 fpm. The normal operating speed is from 42 to 96 fpm depending on the cross wire size. The larger the cross wire the slower the machine must be run. The average speed is about 72 fpm. The maze of hoses are air hoses for the hold down cylinders and cooling water for the electrode guns.

Figure 6 is taken from the operators side of the machine looking across the welder. The larger hoses at the top are air hoses to the hold down cylinders which hold the welding tips down. The air pressure can be varied according to the cross wire size. The pull rod behind the air cylinder is used to raise the electrodes to let them return to the back position (by return springs).

The electrodes return against a bumper bar which is continuously moving, thus letting the weld take place at a different place on the electrode tips.

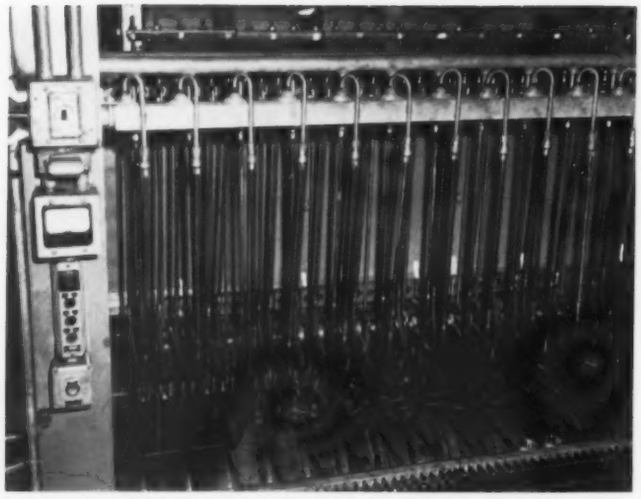


**Figure 5 — The electrode guns are individually water cooled.**

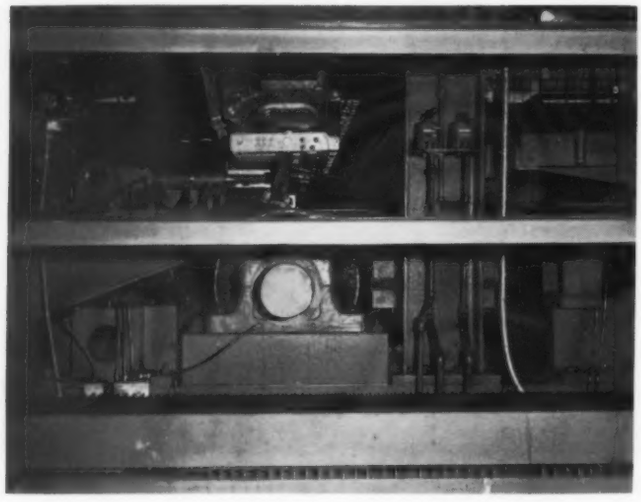


**Figure 6 — Welding of the cross wires takes place at line speed, for the electrode drum rpm is adjusted in relation to line speed changes.**

The electrode drum is a 24-in. diameter copper drum turning at a speed geared to the speed of the line. As the cross wire conveyor brings the cross wire over the drum the top electrode is lowered. When the top electrode makes contact with the transverse wire it starts moving with the wire. At a determined time the guns are "fired" to produce the weld. Then at the proper time the top electrode is raised and returned back to the bumper, ready for the next cross wire. This can best be explained as a continuous walking motion.

When manufacturing mesh it is always necessary to have an even number of welding contacts. When making mesh with an odd number of transverse wires it is necessary to pick up the odd circuit by means of a brush. The brush is similar to the electrode assembly in design except for the addition of the welding brush and adjusting rod and the omission of lift rod and tip. This brush assembly can be shifted to any position on the drum to pick up the odd circuit.

An additional transformer is placed on the welder for use when running the full 13 ft-0-in. widths on 2-in. centers. Flexible cable leads are used for connecting the extra transformer to the last electrode assembly and brush assembly. The extra transformer is also used as a spare in case of failure of one of the other transformers.

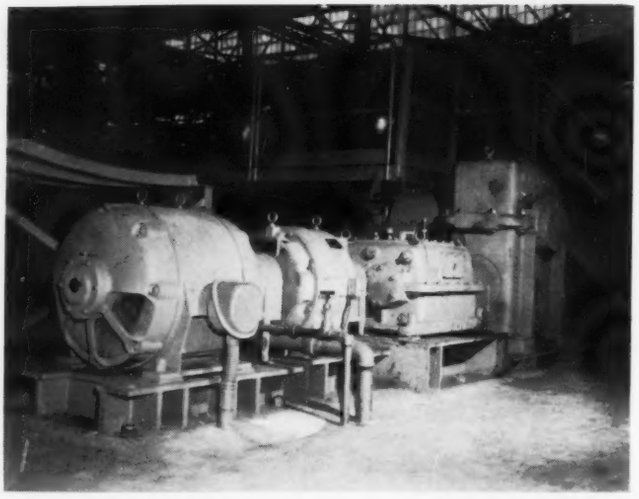


**Figure 7 — A single 100-hp motor furnishes the power for all operation, except the electrode bumper bar movement.**

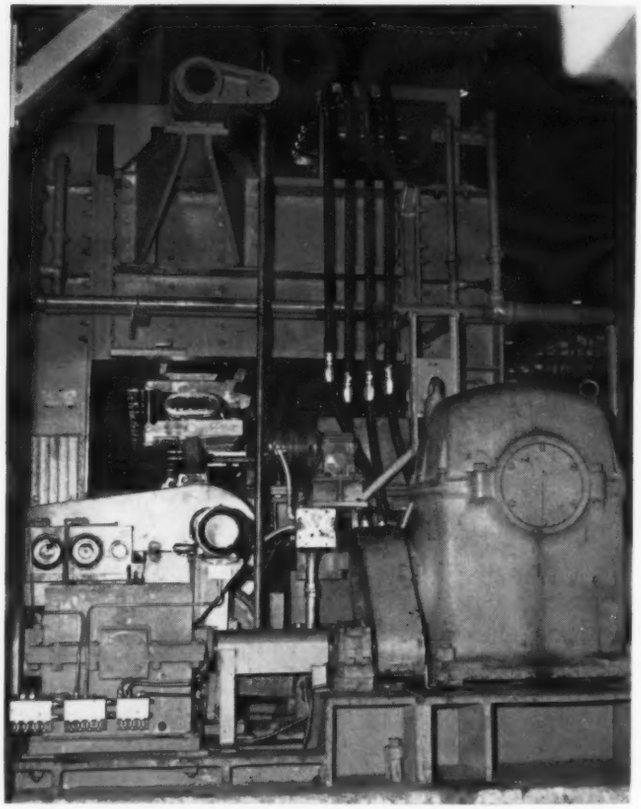


**Figure 8 — The electrode bumper bar is driven by a gear-head motor with an output speed of one rphr.**

A circular type slitter has been designed into the welder. The mesh can be split into various widths or the selvagee can be trimmed to close tolerance. A remotely operated patch welder has also been designed but since the need has never arisen it was never installed.

Figure 7 is a view of the drive for the machine. Every operation but one is a take-off from this drive consisting of a 100-hp motor, an electric clutch type coupling and a 2-speed gear box.

Figure 8 shows the welder from the drive side. At this location there is the pull rod drive, the counter for operating the shear, the trimmer for energizing the transformers and the gear box to change the cross wire

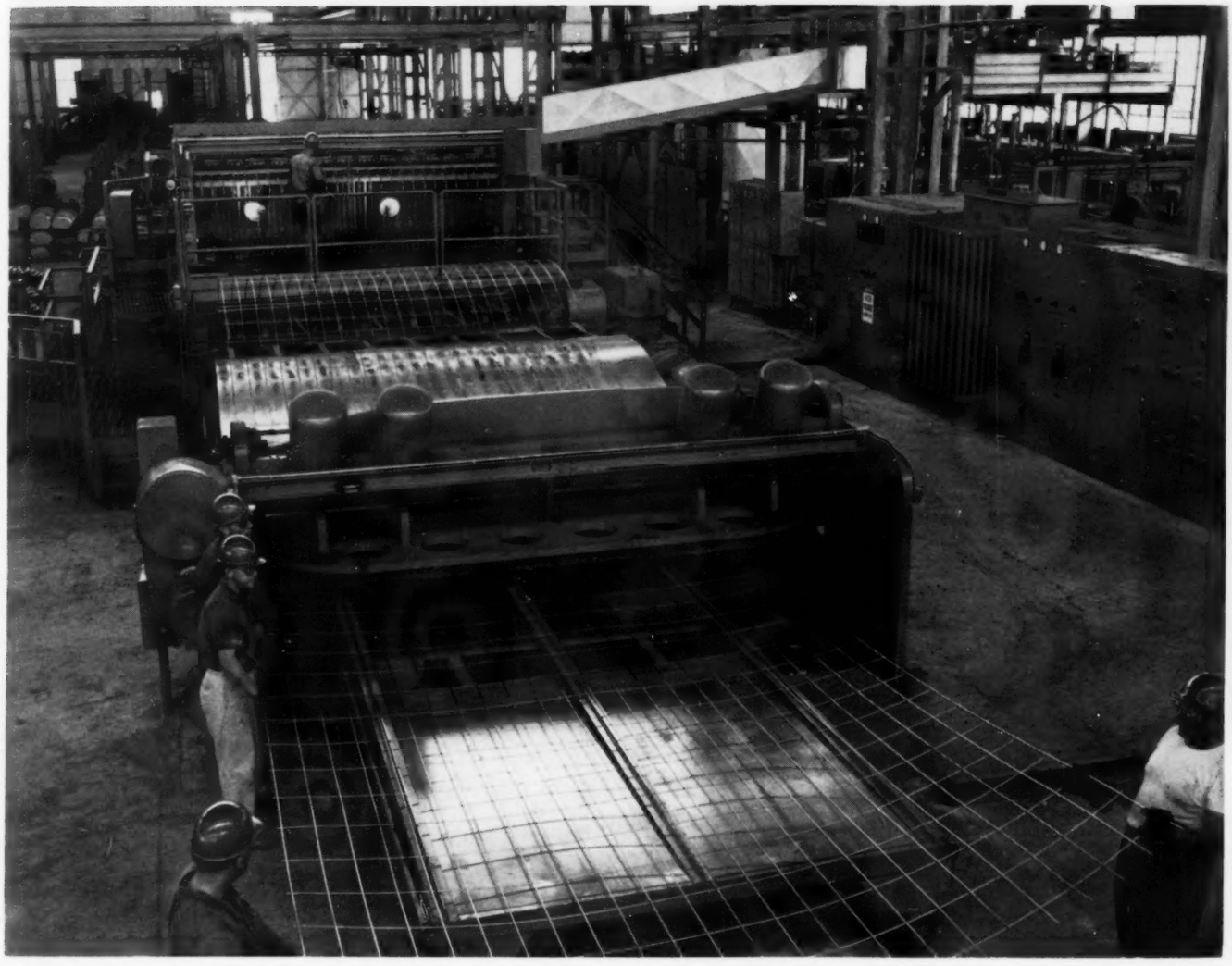


**Figure 9 — The wire can be coiled on either of two mandrels or cut to any size required.**

spacings. The other drive motor can also be seen. This motor with an output speed of one rphr drives the bumper.

There are two coilers with by-parting mandrels. The two coilers permit continuous operation. While the coil of mesh is being tied and stripped from one coiler the other coiler is in operation. The coils can be 13 ft-0-in. wide in one width or split into two equal or unequal widths and 72-in. diameter.

Figure 9 is an over-all view of the machine taken from coiler No. 1. First one can see the cut-off shear. This shear can be timed to cut at any exact setting. Just past the shear is a humping table. This table is similar to any such table used in a strip mill and is used for the same purpose. The humping table allows the welder to continue to run while the shear performs its operations. Total line length is 297 ft. In the background past the welder can be seen the tramrail crane system that operates over the coil storage and feed area. To the right can be seen the electrical transformer and controls. ▲

*There is a constant demand for copies of "The Modern Strip Mill"*

*published by the Association of Iron and Steel Engineers.*

*If your copy is not in use please get in touch with us.*

**ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.**

# Digital Computers for Accounting and Control of Continuous Processing Lines

by R. W. KIRKLAND
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General Electric Co.
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*. . . . computer controlled processes are economically desirable, but the functions to be controlled must be carefully considered with regard to computer cost . . . .*

AUTOMATION is an abused and overused word. Whether it is liked or not, it is the name given to an engineering and management concept that is now a necessity and no longer just a subject for technical papers and arguments.

American industry can turn to no other source for relief from economic pressures. In war the most common question asked is, "What is the situation?"

The steel industry in its battle for profitable, healthy operation, must also each day, week and month ask, "What is the situation?"

The answer is challenging and sobering. The production rate is below 60 per cent of capacity. Steel industry wages are higher than ever before. Modern, efficient foreign mills served by cheap and willing labor are capturing a growing share of the domestic and export market for steel products. New materials are supplanting steel for many applications.

Moreover, these problems are going to increase as time passes. Doubters need only study the history of the American textile industry to discover the pattern. The immediate result today is pressure on each and every mill manager to both reduce operating costs and to increase his company's share of the available steel market.

When mills are operating at or near the break-even point, a few percentage points reduction in costs or a few more tons sold per month can mean the difference between profitable or unprofitable operation.

There are many steel plants in the world today that have modern, efficient machinery equipped with the best available automatic controls. These shops probably also have advanced inventory and accounting systems using automatic business machines and computers.

Accounting and inventory records are an absolutely necessary evil in today's complex industrial operations. Only through this paper work can production be controlled, customers' orders be tracked and scheduled and mill performance be supervised and improved.

The next level of automation now available provides a direct link between the plant control system (accounting) and the individual process control system.

This new device is the industrial type digital control computer.

The digital control computer can both control and communicate. Both features can and should be used since costs are reduced and product saleability increased by improvements in both production and accounting services.

Costs can be reduced by:

1. Increasing production rate per unit of time.
2. Reducing in-process inventory.
3. Reducing in-process scrap loss and damage.
4. Protecting production machinery from damage.
5. Avoiding waste of raw materials.

Sales can be increased by:

1. Improved quality of the product.
2. Prompt filling of scheduled orders.
3. Quick delivery of opportunity orders.
4. Quick response to order inquiries.

## COMPUTERS ON CONTINUOUS PROCESSING LINES

At this time there are 11 digital controlled computers

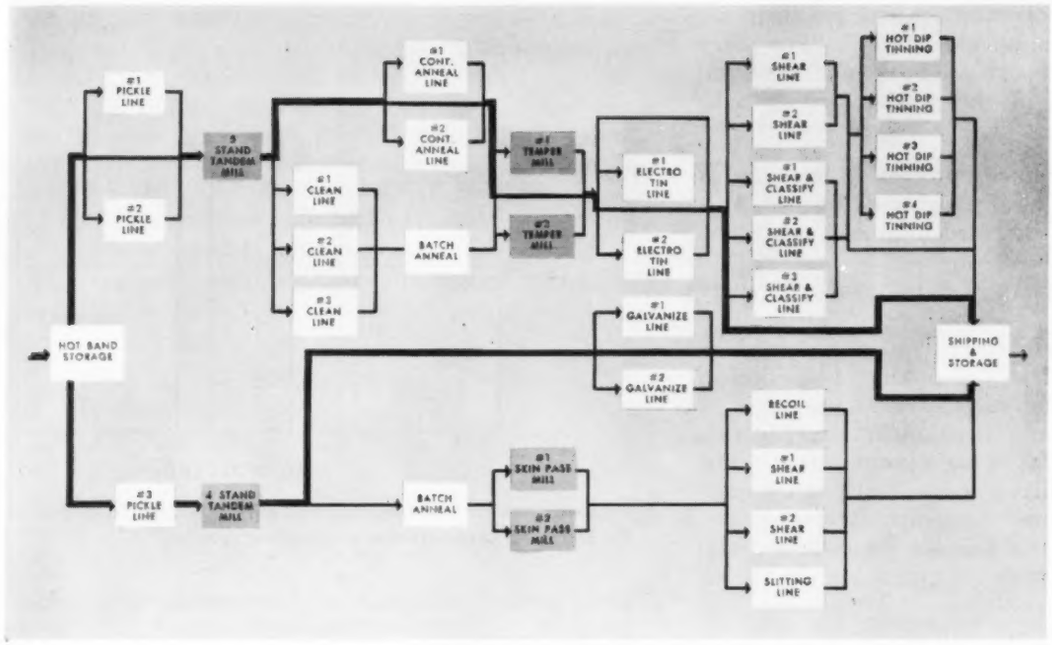



**Figure 1 — Large numbers of specialized lines are being used in today's sheet and tin mills.**

now installed or on order for the steel industry. Four of these computers are being applied to continuous processing lines.

Logically, to date the main effort has been made to adapt these machines to the large rolling mills and steelmaking processes. Small improvements there show large economic benefits.

This emphasis makes good sense and will undoubtedly continue to dominate one's efforts, but processing lines cannot be ignored. They have never been given the same respect and consideration as have hot strip mills, tandem cold mills and the like. Sheet and tin mill operators, though, know that these lines are just as important to the success of their business as the rolling mills. Because of course the simple fact is that these are finishing operations. In many cases they can correct deficiencies in the rolling mills. Their performance also determines the final quality of the product. Secondly, they are more numerous and involve a greater portion of the operating cost and labor than do the higher tonnage capacity rolling mills. Consider a typical sheet and tin mill, see Figure 1. In this simplified case there are 25 processing lines and only six rolling mills.

There are many who would say that the very number of the processing lines in a sheet and tin mill would preclude the fitting of these lines with process control computers. For older mills this would certainly be true.

The long term trend in the development of continuous processing lines however, has led and is leading to the combination of previously separate operations into larger continuous combination lines.

Therefore, in the modern mill an ever-increasing portion of the total production is being handled in only three or four very large combination processing lines. Ultimately, one can expect that many of the small special purpose lines that are so numerous in today's mills will disappear. Tomorrow's sheet and tin mill will look something like that shown in Figure 2.

When a substantial portion of production in any mill follows this process path then it becomes not only desirable but economically feasible for these processing lines to be fitted with digital control computers.

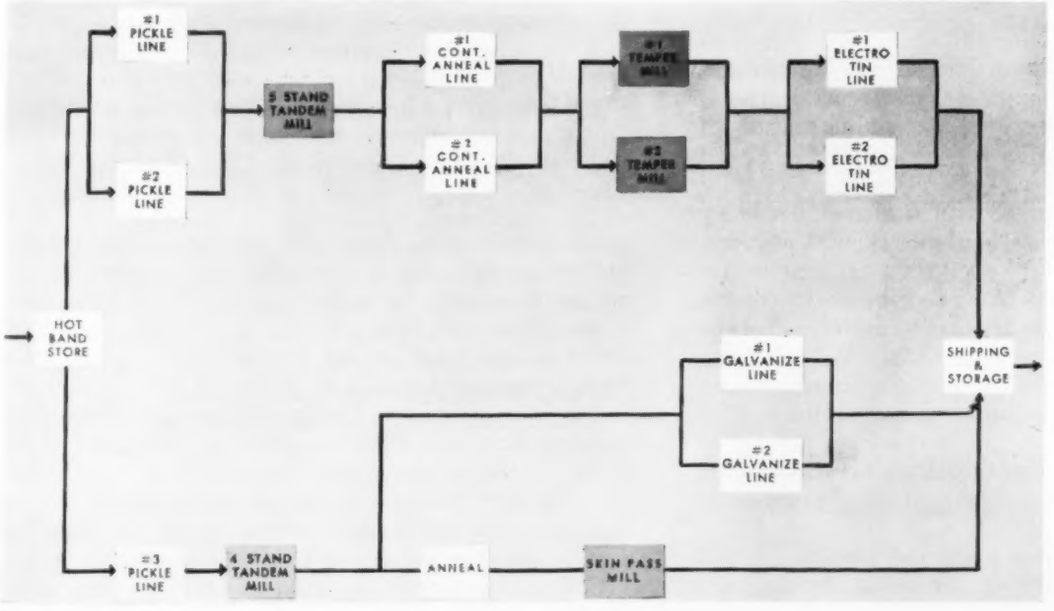



**Figure 2 — Expanded use of computers may reduce the number of special purpose lines required.**

There are a number of valid reasons for their use on these lines. There is an old proverb, "For every action there are two reasons, a good reason and the real reason." Consideration of the good reasons will be first:

1. Modern and continuous processing lines are of recent design and mechanically highly automatic. As a consequence they are easily fitted to process controlled computers.
2. They are very complex since they combine many functions in one line.
3. In the case of tinning and galvanizing lines where material is being added to the product reduction of waste can reduce the cost of raw materials.
4. These processing lines occur late in the production scheme. The material has a high accumulated value and scrap and material loss is consequently much more expensive, see Figure 3.
5. Final quality of the finished product is determined here.

These are a few of the good reasons for applying computers to processing lines, there is a final overriding real reason in the case of tinning lines. Can companies today are shifting to coil form tin-plate orders. These coil form orders have forced tin-plate producers to install special purpose digital type production quality analyzer devices to record and classify the finished tin-plate product on a per foot basis, as it is wound into the finished coil. There are 12 or 13 of these special purpose data accumulators now in operation or on order. In their present form these special purpose data accumulators are simple necessities that offer only limited operating advantages to the users.

The versatile digital control computer, capable of performing all of the functions of the special purpose data accumulators, plus many others, will likely supplant these on future installations.

The preceding has now established the position of continuous processing lines in the steel industry, and it has been shown that digital processing controlled computers are applicable to the control of these processes. The question to ask next is, "What can these machines do for us?"

## DIGITAL CONTROL COMPUTERS

Computers are calculating devices. While there are many types of digital computers, one general type is at present being manufactured for on-line industrial use. This type is known as a general purpose stored program digital computer. General purpose because these machines are designed with sufficient flexibility to be used for many rather than one specified purpose. Stored program because its operating instructions are read in and retained in the machine's internal memory.

The on-line computer is married to a process by the systems' sensing devices, control stations and actuating mechanisms and the special input, output equipment required to permit the computer to communicate with these devices.

The complete logic and mathematics for each action desired from the computer is permanently stored in its operating program.

This program is securely protected from accidental modification or unauthorized tampering. It does not

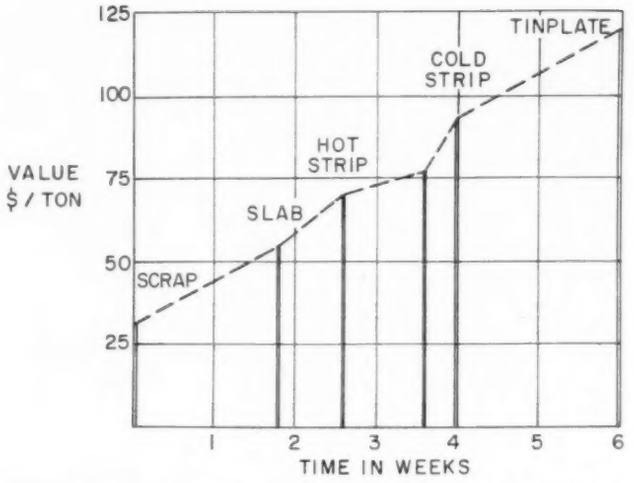



**Figure 3 — Value of the material scrapped is a function of its distance through the processing system.**

decay or age, yet it can be readily changed by skilled programmers whenever new functions are to be added or old ones modified.

Stored program type digital control computers are capable of performing a variety of independent functions by time sharing.

*What can it do?*—A digital computer can observe, compare, analyze and make programmed logical decisions. If provided with the appropriate output equipment, it can report, record and act. It can:

1. Collect process data.
2. Count, add or subtract product increments.
3. Solve equations which include any or all of the input data as variables and control the process accordingly.
4. Locate and identify abnormal or dangerous conditions.
5. Alert the operators for appropriate actions requiring judgment beyond its programmed capabilities.
6. Perform a series of routine operations in a precisely programmed sequence.
7. Compute and print out data on the process and its operation, in the forms most convenient for the operators and the factory accounting system.
8. Register and prepare inventory reports on material in process.
9. Classify produced material according to quality and quantity.
10. Prepare summary production reports by hour, turn or day.

*Use of these capabilities*—All of these abilities can be advantageously put to work on any processing line computer system, for operationally, all modern continuous processing lines are very much alike. They consist of an entry section for loading and preparing the strip, a processing section for doing the line's actual job and a delivery section for finished product inspection and coil removal. They are alike in their method of operation. Being continuous, each coil entered into the line is welded to the tail end of the preceding coil so that a continuous band of strip is in process from the entry uncoiler to the delivery end winding reels.

Coils in orders requiring markedly different operating

practices are joined together and portions of each order may be in the process at the same time. The accounting inventory control of the coils up to the head of each line is on a charged coil basis yet one or more of these coils may be wound into each finished coil. The operators must at all times track and record the location and identity of the charged coils wound into each finished coil. The processes themselves are fairly complex, involving the control of many independent variables.

The functions performed by any given processing line computer application can be divided into seven relatively distinct and independent functions.

1. Weld and coil tracking.
2. Line operation.
3. Data collection.
4. System protection.
5. Quality monitoring and recording.
6. Process control.
7. Inventory and operation accounting.

All of these separate functions are performed by computer system hardware common to all. For clarity they can be described as if they were completely independent operational systems.

## WELD AND COIL TRACKING

Each order of steel must be carefully followed through the processing lines to be sure that the prescribed treatment is given to the coils within that order. The identity of each coil must also be carefully preserved for accounting and inventory reasons. In practice this order tracking is reduced to tracking and identifying the welds joining coils. A computer control system can and must perform this operation in order to synchronize coil identity and processing instructions with the actual material in process. Figure 4 is a sketch of this function. Here the system includes an entry card reader for insertion of coil data, weld position indicating lights along the length of the line, three weld before shear indicating lights and a coil ticket printer or punch.

The loopers in the line are fitted with position measuring transducers. At the instant a weld is made the computer reads the looper transducers and adds this strip footage value to the known fixed strip distance between the welder and the shear. At the same time the coil data are read.

The computer now has the identity and processing instructions for the coil following the weld and it also has the footage from the weld to the delivery shear.

A footage pulse tachometer is located at the delivery section. This transmits to the computer one pulse for each foot of strip that passes the delivery shear. These footage pulses are subtracted from the measured welder to shear length so that the computer knows at all times the position of the weld with respect to the shear. The position of the weld is indicated to the operators by the line weld position indicating lights.

Since each finished coil is normally terminated at a weld, it is necessary for the operators to know in advance when a weld is approaching. Many late model high speed lines have a limited storage time in the delivery loopers. This storage is seldom more than 60 sec. It is very important for the operator not to initiate slowdown too soon, otherwise he will exhaust the looper and be forced to slow down the processing section.

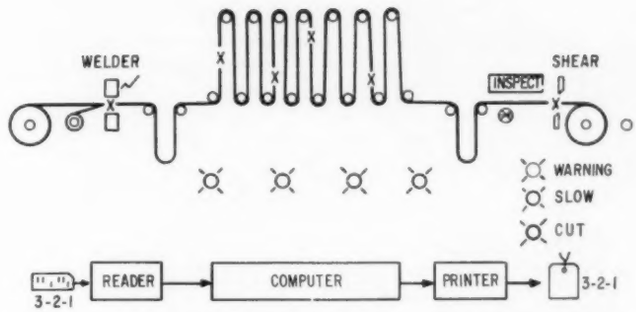



**Figure 4 — The computer can track coil identity through a continuous processing line.**

In the same manner, it is equally important that he does not initiate slowdown too late, otherwise the weld will pass the shear before he can detect it and make his cut.

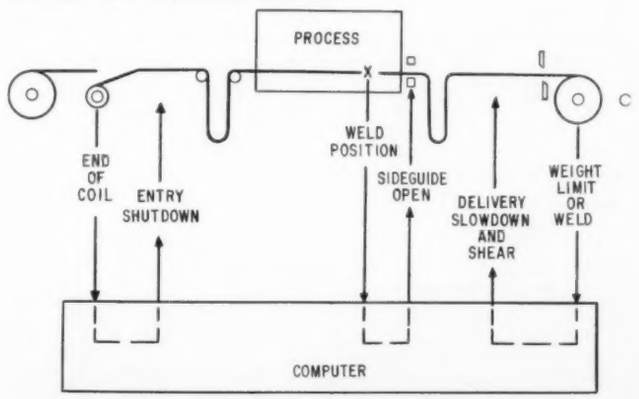
The computer system knowing and tracking the position of each weld and also scanning line operating speed can warn the operators of the approach of the weld on a time basis. For example, ten sec out a warming light will be energized at the delivery desk telling him that a weld is approaching. At a calculated time, depending upon the deceleration rate of the delivery section, the slowdown light will be energized telling the operator to initiate slowdown so that the weld is just before the shear when transfer speed is reached. The final cut light is energized when the weld is at the shear.

The computer in addition to tracking the weld must also track through its own memory system the order data pertaining to each charged coil. A finished coil ticket may be punched or printed at the instant each finished coil is sheared. In this manner the identity and inventory data of each coil can be retained. This weld and coil tracking feature or function is a necessity for any processing line computer since it determines the sequence and time in which the computer's actions are performed.

## LINE OPERATION

The computer system can perform many of the operations common to the operation of the line itself. Large high speed processing lines contain a tremendous amount of equipment over and above that in the central processing section. This equipment is needed to transport and handle the coils and the strip. The computer can help. Figure 5 shows three or four of the possible computer actions that can be provided to help the line operators.

**Figure 5 — Operations along the length of the processing line can be computer actuated.**



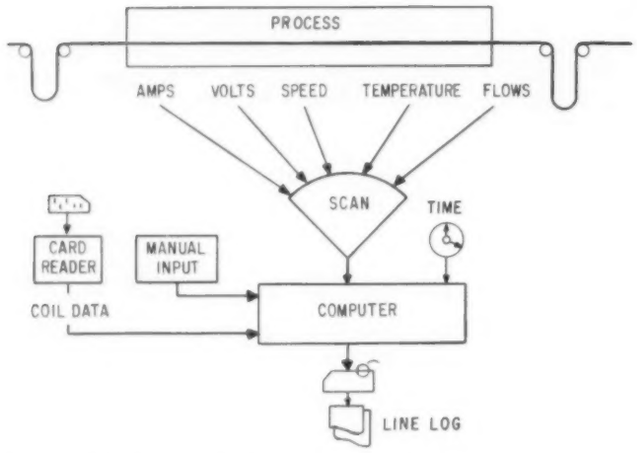



**Figure 6 — Process information can be assembled, converted and typed out to provide a quick analysis and material correlation for product testing.**

*End of coil entry shutdown*—The entry operators must like the delivery operators shut down their line section at just the right moment to avoid exhaustion or overfilling the entry looper.

The computer system can perform this operation by monitoring payoff reel speed, line speed and strip thickness.

A simple calculation at the beginning of each order permits the computer to develop the reel mandrel speed vs line speed value at which shutdown must be initiated to leave a specified length of strip or number of wraps on the reel mandrel.

*Sideguide positioning*—On many lines sideguides and strip centering devices are provided to keep the strip running straight through the process. These devices may be damaged when wider strip is joined to the tail end of preceding narrow strip and the sideguides are not reset in time. The computer, tracking the welds through the process and scanning the order data, can determine when these transition welds are approaching each of the sideguides through the line. A safe distance in advance it can operate these sideguides to bring them safely clear of the wider strip. If the sideguides are fitted with position regulators, the computer can move these to the proper opening for each order.

*Delivery slowdown for welds*—The computer system can automatically slowdown the delivery section and operate the shear to cut at any coil weld. The slowdown and cut sequence will usually be done manually with computer assistance, since several charged coils may be wound into one finished coil and it is somewhat difficult to tell the computer which weld to cut and which to pass.

However, there are some can companies who specify coil form orders containing no welds. For these orders the computer can be permitted to automatically cut and transfer reels. The precision of the computer can be relied upon to always cut just after the welds so that the weld is always on the outside of the finished coil where it can be easily removed.

*Automatic finished coil weight limit*—Many can companies are now specifying maximum coil weights for their coil form orders. The preparation of such coils is something of a problem for tin-plate producers. This problem is even further compounded when the can company order specifies a certain weight limit and in addition specifies that this order contain no welds.

The computer system here can perform an extremely useful function. With considerable precision the computer can calculate the running weight of each finished coil as it is wound on the reel. When the specified weight is approached, the computer can automatically slow down the delivery section of the line, shear and terminate the finished coil, and automatically operate the reel transfer sequence to start the next coil.

## DATA COLLECTION

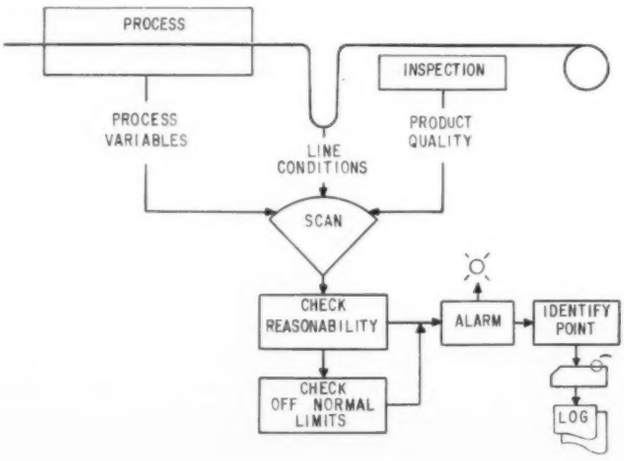
The operation of the central processing unit in any processing line is, after all, the most important portion of the line, whether it is an annealing furnace, plating tank or a galvanizing pot. These processes are fitted with a wide variety of sensors and recording instruments to provide the operators with the data needed to continually monitor and control the actual performance of the processing section. The collection and analysis of this information using conventional strip chart recorders and analog indicating instruments is a laborious process. The results are almost never correlated with the product being processed at the time the readings are taken. As a consequence, cause and effect analysis is difficult without special effort involving a number of trained observers.

The conversion of these data to numbers for scientific analysis is laborious and subject to human error. The digital computer, however, can read any number of analog signals from the vital portions of the process. It can correlate these with the order and material being processed at the time the readings are taken. It can if instructed reduce these data and make any programmed analysis required. The data collected in this manner are immediately available and in a form requiring no further manipulation.

In the example in Figure 6, the computer is fitted with an input card reader, a manual input station and a scanner for reading and measuring any number of analog signal inputs.

The computer on demand or at preset intervals of time will scan all the analog input signals, convert these to numbers and type them out on a line-log typewriter, tape or card punch, correlating all of the readings taken with data on the material being processed at that time.

**Figure 7 — Constant product and process investigation limits off-quality material and protects the processing line itself.**



## SYSTEM PROTECTION

A computer system even though it adds complexity can contribute to system reliability. It can do this by monitoring the action of the line machinery, quality of the finished product and the many process variables in the process itself. Dangerous conditions can be detected in time to prevent serious damage.

In the example shown in Figure 7, this protection is provided by two system checks. The first reasonability will detect sensor failure. The second off-normal will detect process failure. The reasonability check is the computer's substitute for human scepticism. The computer scans each reading from each line sensor, checks it against the preceding history of that particular value or a known maximum rate of change. Should it show any abnormal deviations, the computer will logically assume that that sensor has failed and sound an alarm. If all of these variable sensor signals pass the reasonability check, they are then compared to programmed high or low limits, and if these limits are exceeded the alarm is sounded.

As each abnormal condition is detected, in addition to sounding the alarm the computer can identify the point and its value at the time detected, on an off-normal typewriter or other logging mechanism.

## QUALITY RECORDING

The growth of coil form orders for tin plate has resulted in the development of elaborate continuous inspection and defect tallying equipment.

Digital control computer systems can perform this function at lower cost and with better results than the special purpose equipment now being used.

The special purpose equipment can only total the footage defect tallies and categories. The log sheets produced are listings of these totals plus the time and other operator inserted data.

The computer system on the other hand can do all of these things and much more. Figure 8 is a simple sketch of this computer function. Here the computer uses its order tracking function and its calculating ability to operate the complete inspection system.

As the head end of each new order approaches the inspection table, the computer resets the deviation type gages to the new nominal setting. The various classifier devices, which may be a part of the computer system, are also reset to any required new band settings.

Each foot of strip is thereafter inspected and classified into various defect categories, shifted down to a common point on the shear to avoid double rejection and totaled for each coil. These defect coil totals may also be accumulated in various defect categories such as prime, mender and waste waste. At the end of each coil the computer summarizes these totals and computes the percentage of strip within that coil within each defect category and, if required, the number of tons or lb within that category. These results are automatically typed out on the coil log typewriter or transmitted to central accounting system through punched tape or punched cards.

## INVENTORY AND LINE ACCOUNTING

The on-line computer is capable of collecting, arranging and analyzing all the information required by the

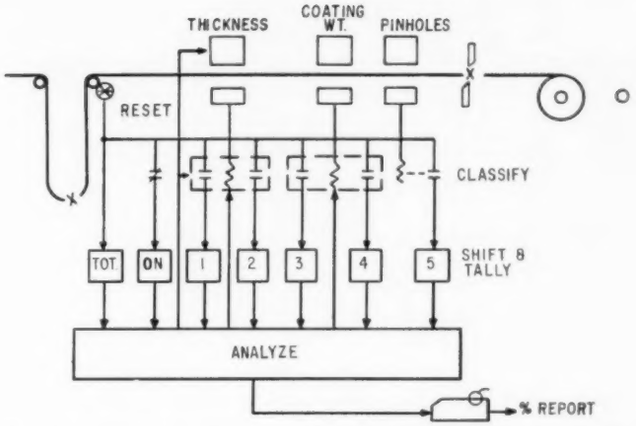


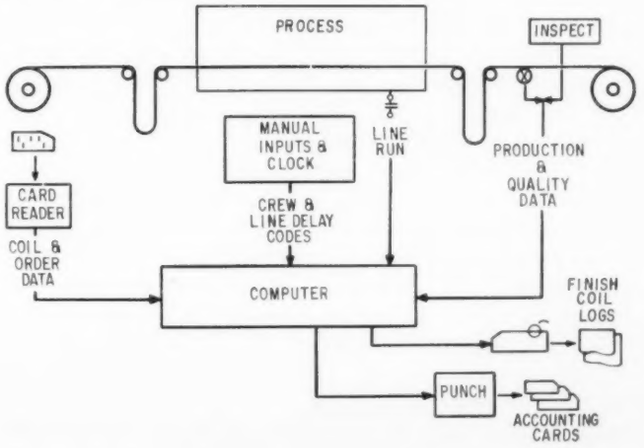

**Figure 8 — The complete inspection procedure can be handled by the digital control computer.**

central accounting system for pay records, production data or inventory control. These records can be transmitted to the central accounting system through wired connections to other processing machinery or to tape or card punches, see Figure 9.

The amount and nature of the information required for each installation will vary depending upon the user's practices, needs and opinion. Some representative accumulations however which could be provided are:

1. Inventory
   a. Charge coil numbers.
   b. Order numbers.
   c. Finished coil numbers.
   d. Coil weights.
   e. Processing time and date.
   f. Total order weight.
   g. Dimensions and data.
2. Production
   a. Tons per hr.
   b. Total turn tons.
   c. Percentage in each defect category.
   d. Utilities consumed.
3. Accounting
   a. Crew and operators.
   b. Tons produced in incentive classification.
   c. Line delay time.
   d. Delay explanation.
4. Operation
   a. Line and process variable values.

**Figure 9 — Accounting information can be collected to provide pay records and production data.**



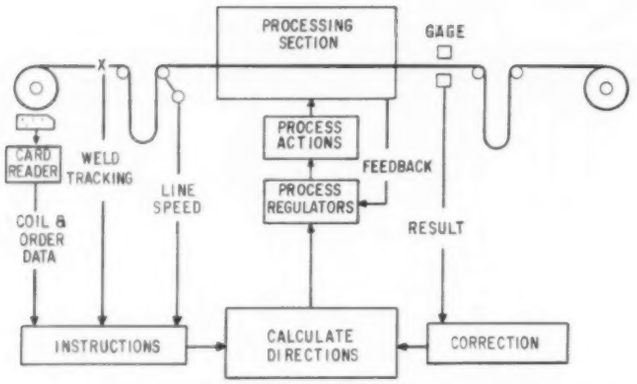



**Figure 10 — Automatic direction of the process is controlled by continuous monitoring of the computer.**

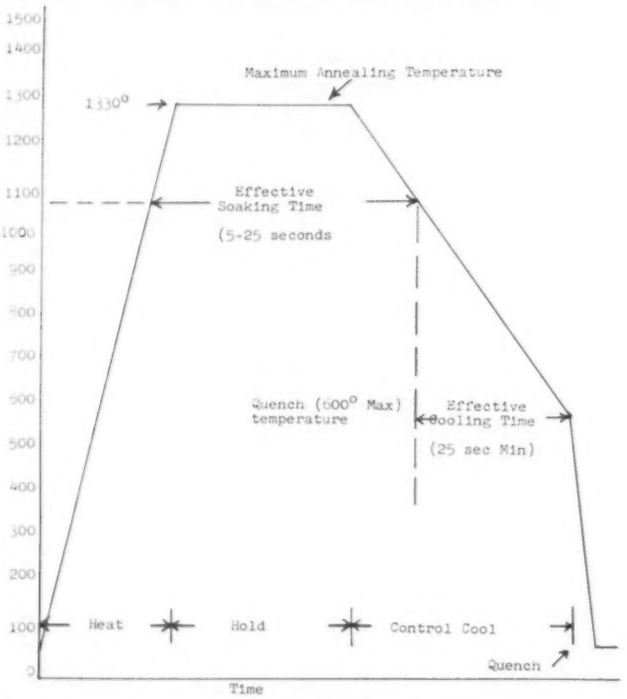



**Figure 11 — Close control of the annealing cycle is important in the production of quality strip.**

b. Material data.
c. Product condition or quality data.

## AUTOMATIC PROCESS DIRECTION

The most valuable contribution of any computer control system certainly will be the automatic direction of the processing section. The details of each process control action will vary according to the type of line. However, the general operation is functionally similar for all processing actions. Figure 10 is a simple block diagram of such an action. The coil and order data for each coil charged on the line are fed into the computer by means of punched card, punched tape or manual input. As the head end of that order tracks through to the processing section, the computer calculates the operating instructions required on that particular order. The computer continually monitors line speed and alters the process instructions as required. As the head end of each order enters the processing section, the computer transmits these operating instructions to the process regulators. Tracking the order and the welds through the line, the computer checks the results of the processing action and calculates new directions to correct any errors made in the first setup.

The various processes found in sheet and tin mills are totally unlike one another in principle and detail even though they have similar operating problems.

Careful consideration of almost any process will reveal actions and functions that are known to be desirable but heretofore not practically achievable due to the limitations of either the available equipment or of the operators.

Consideration of the annealing process will illustrate this point.

In this process work hardened strip is put through a carefully controlled heating and cooling cycle (Figure 11) to restore its ductility. In the continuous annealing line this cycle is performed by passing the strip through a vertical furnace as shown in Figure 12.

This continuous annealing process would seem to be a very simple operation. However, in practice this is somewhat complex because of:

1. The furnace is an effective heat sink and zone temperatures cannot be changed rapidly.
2. The incoming strip varies in its dimensions and characteristics. Strip on an order requiring one annealing practice is welded to the end of a strip from an order requiring a different annealing practice. Portions of both orders may be in the furnace at the same time.
3. The annealing cycle involves both temperature and time. Strip temperature depends upon zone temperature and the time the strip is in the zones. As a consequence any variations in annealing cycle time base by speed adjustments will also change strip temperature.

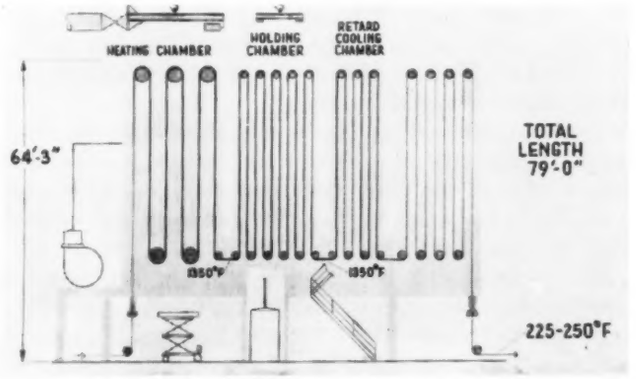
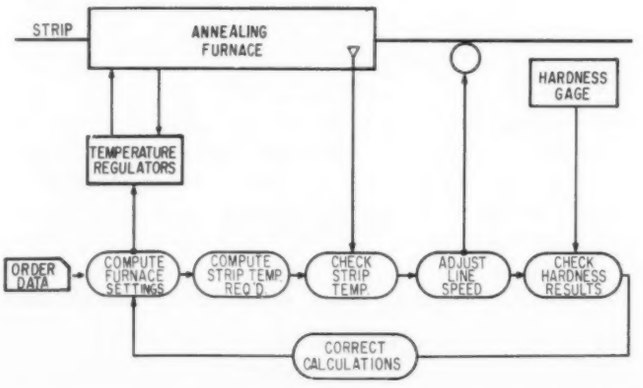



**Figure 12 — A typical annealing furnace will produce 30 tons per hr at a strip speed of 1000 fpm.**

**Figure 13 — Computer quality checks permit continuous regulation of the annealing process.**



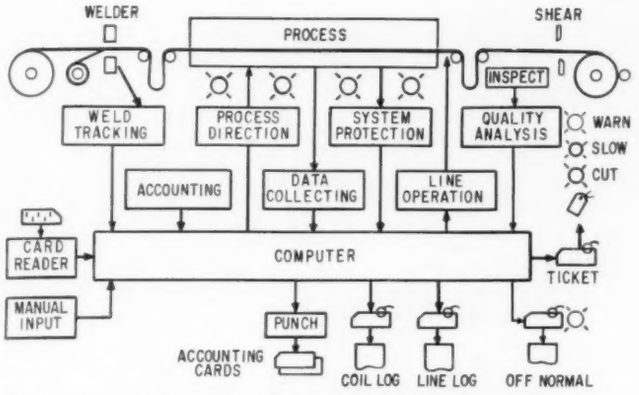



**Figure 14 — The application of all available functions to a single process line could be an extremely expensive operation.**

There are 14 or 15 continuous annealing lines in this country that are being very successfully operated without computer assistance. However, the practical difficulties of furnace adjustment make it highly unlikely that they are being operated at peak efficiency. The line operators hold hardness by varying line speed and order changes require considerable trial and error experimentation.

The computer can provide predictive and adaptive hardness regulation by operating as shown in Figure 13. Use is made of the fact that within each order finished hardness is reasonably proportional to maximum strip temperature. As each new order enters the furnace, the computer calculates the furnace zone temperatures and maximum line speed to achieve the best annealing cycle. Since zone temperatures cannot change quickly, the computer acts to bring strip temperature to the calculated value by varying line speed.

As the zone temperatures approach their final value, line speed also is automatically brought to the calculated cycle value. The program can be written, in many cases, so that this cycle transition is made with a minimum disturbance to the hardness of the tail end of the preceding order. Final closed loop corrections are made to the annealing cycle by scanning periodic or continuous readings of the finished hardness.

By now any alert and normally harrassed sheet and tin mill operator should be interested enough to want three of each function in a paper sack. What could such a system look like? Figure 14 combines these separate functions into an integrated processing line computer control system.

However, do not rush too recklessly down the automation road to effortless production. These functions are relatively cheap when provided by computer time sharing, but they are not free. You must pay for them in both dollars and careful planning. Presently available industrial computers can do almost any number of things within reason that an interested user can think of, provided it is given time to perform them. They can also do one or two functions at a remarkable rate of speed. And they can probably do a combination of both, provided the user is prepared to pay the price. The economic truth is that the cost of any given computer system is somewhat proportional to a factor of functions times speed times required accuracy.

Since today's computer systems are built in modules, the curve of cost vs this FSA factor is a series of ascending steps starting at a base price of $75,000. The addition or deletion of a small function consequently can often change the system cost by an amount much greater than the function itself is worth.

System planning therefore should consider all possible useful functions and should require each of these to justify its existence.

## THE FUTURE

It is certain that the steel industry and all industry is going to be subjected to growing economic and competitive pressure.

Automation which began with the stone age discovery of flint tools will continue to be the main source of relief from these pressures. Digital control computers providing faster links between cause and effect will permit the development of even larger and more efficient processes. In time it will prove to be economically desirable and perhaps even necessary to integrate all of the rolling mills and processing lines into a plant wide system (Figure 15) that can permit a large high capacity plant to be as readily controlled by its management as the small shop of 75 years ago. This integrated sheet and tin mill will be more specialized and will have fewer mills and processing lines. Larger and more complex on-line computers will make this possible. ▲

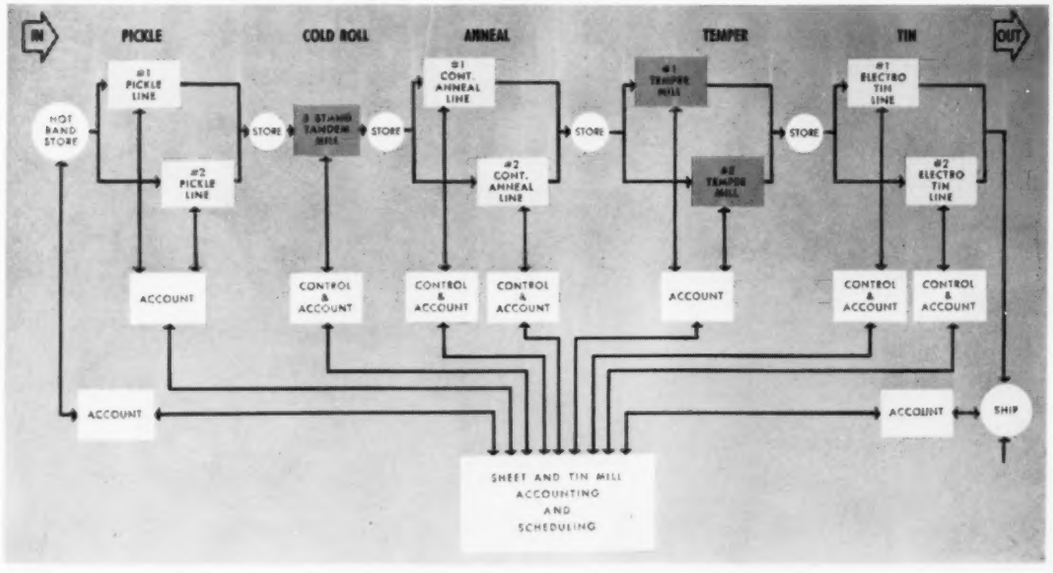



**Figure 15 — A plant wide tin-plate process material flow, control and accounting system may prove to be economically necessary.**

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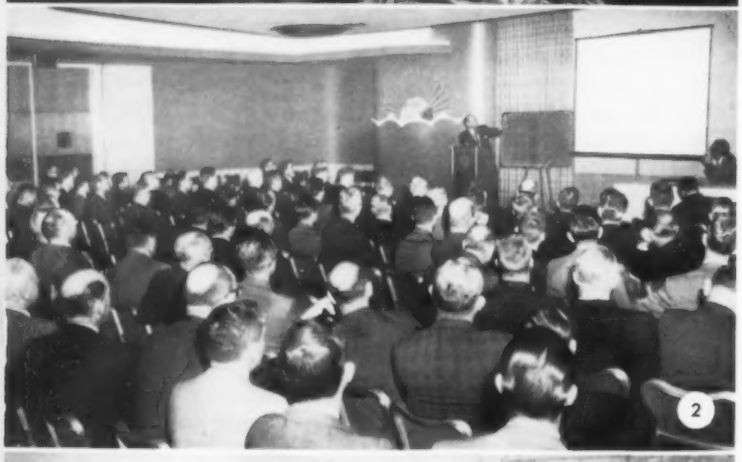

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# *Pictorial Roundup*

# AISE Western Meeting

## Los Angeles, Calif.

## February 27, 28, March 1

Some 422 men (1) registered at the 1961 Western Meeting of the AISE held at The Statler Hilton, Los Angeles, Calif. An interesting technical program drew the interest of the registrants. W. E. Miller is shown (2) talking about process control in Russia. Leading the Monday afternoon session were W. F. Pruden, an author, Louis E. Ringger, chairman, both of Columbia-Geneva Steel; W. B. Jacobsen, speaker, and J. B. Wylie, chairman (3). On Monday morning's program were (4) W. H. Dauberman, W. E. Miller and Donald Stewart, all authors, seated; and standing, chairmen, Harry Riegel and S. F. Mazur.

The program for Tuesday morning is here being outlined (5) by the two chairmen, R. J. Tremblay and Jerome L. Lindberg, third and second from the right, respectively; and by the authors Ed Kurzinski, Fred W. Farmer and, on the extreme right, J. W. Irvin. This session's emphasis was on iron and steel refining operations. Tuesday's afternoon program was carried out (6) by James E. Reider, John A. Bauscher and John D. Sprowl in a session chairmanned by W. L. Murphy and R. L. Dowell, all shown from left to right.

Detroit was well represented (7) with Phil Ashurst, secretary, James L. Laidlaw, AISE board member, and William Collison, a past president. AISE western sections chairmen present included (8) J. B. Wylie, San Francisco; Jerome L. Lindberg, Colorado; Harry Riegel, Los Angeles; and F. T. Hickenlooper, Utah. One of the outstanding talks was given by Fred W. Farmer (9) of Lone Star Steel on blast furnace injection. Official host for the meeting was Charles Pritchard, president, AISE, who is here shown talking to the dinner speaker, H. C. McClellan (10). Mr. McClellan in an interesting speech outlined problems which American industry must face from foreign competition. (See page 148.)

Some of the representatives of local steel industry management at the dinner (11) are: Ruben Finkelstein, vice president, Southwest Steel Rolling Mill, Inc., and Barney Dagan, works manager, Kaiser Steel, Fontana, who was also host to the AISE members on an inspection trip to the Fontana works of the Kaiser Steel Corp. on Wednesday. Many informal gatherings featured the meeting. One of these is here shown, left to right, (12) Ken Casey, Kaiser Steel; H. P. Dotson, Columbia-Geneva; Bob Prout, Columbia-Geneva; W. A. Curran, National Roll and Foundry Div., General Steel Castings; and Reynold MacDonald of Kaiser Steel.

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# A New Horizon in Management Planning

by H. C. MC CLELLAN,
President,
Old Colony Paint & Chemical Co.,
Los Angeles, Calif.

*. . . . talk given at banquet of AISE Western Meeting, Los Angeles, Calif., February 28, 1961 . . . .*

AS WE of business and industry, the management men of the market place, undertake to orient ourselves into the circumstances of the new year, to estimate our opportunities for progress, to plan toward continued prosperity and for a bright and peaceful future, it seems wise that we take a wider look than has been our habit in the past. By a wider look is meant a look beyond our shores for during the 60's we shall see increasingly strong influences upon our daily lives which spring from activities abroad.

If we would accommodate ourselves and our industries to these new influences successfully it is essential that these new influences be recognized now, that they be analyzed and be fully understood, not merely by officials in Washington, but by businessmen, especially men of management everywhere. For we are the ones who will be responsible in the main (and properly should be) for shaping both policy and method by which a whole new set of problems will be met.

Our willingness to learn, our ability to understand and our genius for dealing with seemingly insurmountable difficulties through resourcefulness and imagination are about to be tested anew. This is our thesis.

During less tense times when activities in other lands seemingly at least held promise of less effect upon our own economic welfare most businessmen except those directly engaged in foreign trade or defense production have paid small attention to problems international. Most of us have in the past assumed, for example, that our domestic market is so large that foreign markets are not important.

Furthermore our internal economic complexes involving labor issues and home grown competition have made such demands upon our energies and abilities that we have had little time to concern ourselves with such distant difficulties as disputes over Suez, the French failure in Indo-China, financing of the Aswan Dam, or Russian intervention in Guinea.

We have been disposed, most of us, to leave foreign relations problems to the State Department. We have, however, quite properly always felt free as hard-headed businessmen to criticize and especially to complain when so many of our hard earned tax dollars have been spent overseas and when sometimes those dollars were seemingly wasted.

Today, however, the situation is different. The businessman's interest in foreign affairs is no longer merely academic or philosophical. Every alert businessman knows that at least one factor in his prospects for future success has been sharply changed; that factor is the impact of the huge volume of manufactured imports from abroad. Whether or not we are now directly engaged in foreign trade none of us is completely exempted from the effects of this development.

To illustrate this fact consider steel. Long recognized as a basic commodity in the United States economy it is notable that almost 90 per cent of the nails now used in this state (California) are imported. So also are more than 50 per cent of the butt-weld pipe supplies which are used extensively in piping gas, oil and water. During 1959 steel products imported into California totaled

614,000 net tons, an increase of 127 per cent over the previous year. Obviously the impact on the economy of California cannot be ignored.

Steel product imports are merely an example. Ceramics, cotton goods, glass, chemicals, plastics, electronics, radio and a myriad other items also are importantly involved. As further illustration, during 1959, 50 per cent of all sewing machines sold in the United States were made in Japan. Today many American firms, including some here in Southern California, are finding it expedient to install factories abroad in order to remain competitive. We must as businessmen widen our horizons as we consider the business outlook for the year 1961 and as we formulate our plans for future management of our business affairs.

From my viewpoint this practical problem of foreign competition, serious and threatening as it truly is, cannot be regarded objectively nor dealt with successfully unless there is willingness to deal realistically with the whole broad problem of international economic relationships, and perhaps also to give consideration to the collateral problems of national foreign policy, for our growing import competition is in part at least a consequence not a cause of difficulties we must face in this decade.

Our basic foreign problem involves much more than trade alone. Our trade trouble itself involves much more than low priced imports. The first point then is this: all of us are now inescapably involved in the growing problem of foreign trade relations. While this is not a new problem its dimensions in relation to our over-all economy and to our national tranquility and progress are decidedly new. Management men must think and plan accordingly.

Unfortunately contrary to the view held by some there is no easy solution. Every school boy knows that if we would export we must also be willing to import. Every sophisticated businessman knows that to the extent at least that we impose restrictions on imports into the United States nations trading with us will restrict exports to their shores.

Most of us are aware that during the past year of 1960 the United States exports totaled nearly $20,000,000,000. Our exports not only exceeded imports by approximately $5,000,000,000, but it is noteworthy that the bulk of United States exports were made up of manufactured goods with a heavy labor content while imports were more heavily weighted by raw materials and semi-processed items shorter on labor content. Clearly as of now the over-all trading advantage is ours, our problems notwithstanding. We can scarcely afford to sacrifice the economic benefits over-all which now accrue to our nation.

It is our suggestion, that we examine carefully the circumstances of those nations whose attitudes and whose future actions are likely to affect us most. Time does not permit a broad discussion country by country. The best we can do for the purpose of illustration is to report the interesting circumstances of Japan, a major exporter to the United States, a nation vitally important to all of us especially to California and the West Coast area. Japan is important for reasons above and beyond those purely commercial.

Japan consists of four main islands, together with 1000 smaller islands extending 2000 miles along the East Coast of Asia. To the West is Communist China. Across the Sea of Japan is Russian Siberia, Northern Korea, which is Communist, and Southern Korea which is free world oriented.

Japan's population today lives almost entirely upon her four principal narrow, rocky islands which offer desperate scarcity of arable land. Less than 14 per cent of her land area can be cultivated. Life is hard.

Japan must import 20 per cent of her goods and 80 per cent of her raw materials including the exceedingly important iron ore consumed. There is virtually no oil. Having lost 45 per cent of her territory during World War II Japan's 93 million souls must live on a land area smaller than the State of California. Tokyo is the world's largest city with a populace totaling 10,000,000.

Japan has one major resource and that resource is low priced labor. She is confronted with the necessity to export that labor in the form of finished goods and services in order to live and to pay for the food and the raw materials required.

At the close of World War II one half of Japan's homes and buildings in 36 major cities had been burned out. Some 80 per cent of her industrial plants had been destroyed. Her merchant fleet was sunk or out of commission.

But today Japan is again one of the world's major industrial powers. She now produces three times as much as she was able to turn out before World War II. During the past four consecutive years Japan has led the world in shipbuilding tonnage. In 1959 Japan was the fifth producer of steel in the world, exceeded only by the United States and Soviet Russia, Western Germany and the United Kingdom.

Even life expectancy in Japan has risen since the war from 50 years to 65 for men and for women to 70 years. The greatest progress of all, however, has been made in the field of foreign trade. In 1950 Japan's exports totaled $7,820,000, inadequate to cover the cost of food and raw materials needed. During the period of 1946 through 1956 Japan's trade deficit totaled $6,000,000,000 and much of this deficit took place because our sales to Japan were in excess of her sales to the United States.

By 1959, however, exports from Japan were expanded to approximately $3,500,000,000 and this export total was made almost entirely to the free world nations. Last year Japan's exports were just over $4,000,000,000. Japan has again become a strong industrial nation and a vigorous competitor in world markets.

During 1959 the trade tide turned between the United States and Japan. This was the first year since World War II when Japan's exports to the United States exceeded our sales to her. In 1960 the trade balance between our two nations was close to balance.

Even though this trade balance now apparently is continuing, manufactured imports from Japan are currently upsetting numerous American industries and are threatening injury to many more. In the light of the changes taking place there is a real need to improve our over-all trading pattern with Japan. We need, for example, to persuade the Japanese to ease some of the restrictions which still remain against the entry of American goods into Japan. We also need to safeguard our own domestic market against exploitation. We say exploitation in terms which infer a clear distinction

between exploitation and creative marketing.

To make trade adjustments between the United States and Japan toward the expansion of healthy, mutually beneficial trade relations between the two countries will be a difficult diplomatic task. This is true in part because of the pressures which are about to be applied toward restricting imports from that nation.

As the task is undertaken, however, as it surely will be, to improve our trading pattern we Americans must realize that we can afford neither to lose our markets in Japan nor to turn Japanese trade, together with Japanese loyalties, to the East. The Russians would like nothing better than to encompass Japan in the Communist orbit. The chain of Japanese islands is invaluable to Western defense and the Russians know this.

Of no less importance so far as Russia is concerned is Japan's vast industrial plant and equipment. Japan stands today as the greatest single obstacle to Communism in Asia. Should this little island nation ever become part of the Communist world it would be an incalculable loss to the United States, to the free world and to the Japanese people.

Our problem clearly is a sensitive one for many reasons. Quite frankly even recognizing our generous post-war aid the Japanese simply could not understand the American resistance to their efforts to export to us during the difficult recovery years. We can assure you from personal experience in Washington that the resistance was real even during the period when Japanese purchases from us were running hundreds of millions of dollars annually greater than our purchases from Japan. Japan does not fully understand even now the resistance offered to her sales to America.

Japan is due great credit for her miraculous recovery based upon self reliance, ingenuity, her people's willingness to work, to save and to sacrifice. Japan is in the main wholly a friend and an ally of the West and of the United States especially. This notwithstanding the dramatic demonstrations staged in opposition to the United States-Japanese Security Treaty.

With reference to those unfriendly demonstrations we should bear in mind that the Japanese people have never quite forgotten the two atom bombs at Hiroshima and Nagasaki, nor the 106,000 dead and the tens of thousands injured.

We should realize also that the Japanese military class, formerly concerned with national security and with international defense alliances, was eliminated by the United States during the period of occupation.

Finally we should realize that the disastrous defeat suffered by Japan with great loss of territory, wealth and prestige, left her occupied for the first time in her history. This has understandably filled the Japanese people with a deep conviction that they want no part of any agreements or activities which might again lead them into war.

There are many in the United States mindful of American aid given Japan who would impose sanctions against Japan to display our displeasure when things go wrong. There are also numerous groups in American industry faced with difficult and sometimes unfair competition who demand extreme measures through quotas, high tariffs or even embargoes to protect themselves and their companies against Japanese imports. Recently these groups have been joined by some of our American Unions.

The consequences of such drastic actions, if taken, would be far-reaching indeed. Yet in the months ahead the issues involved simply must be met. This in my judgment will require the wisdom of Solomon, the patience of Job and the human understanding of Abraham Lincoln.

The circumstances of Japan and our somewhat tenuous relations with that country serve to illustrate how complex our international economic affairs have become. They serve to demonstrate how difficult it is to work out practical, equitable, durable solutions. It seems obvious however, in the light of the realities described that we of business and industry dare not rely unduly upon government imposed tariffs or quotas or upon import embargoes to safeguard our domestic sales against shipments from abroad, even though some American industries are already insisting that our government provide such protections.

We firmly believe that during the 60's we will out of necessity be required in large measure to cope with the new international influences through our own resourcefulness and ingenuity. In some instances we must modify production as many have already done successfully in order to sustain a profitable market for our wares.

Here we will make a prediction. The new administration in Washington is not in my judgment likely to turn protectionist. The stakes are too high and the risks are too great to permit.

We live in a smaller world than formerly. Our country is not now completely independent of other nations either politically or economically. We must have allies upon whom we can depend during these trying times. We must also have customers overseas to buy our export products. Millions of Americans rely upon such trade for their livelihood.

To attain these objectives we must adjust our thinking to things as they are, not as we might like them to be. This is no time for economic complacency. There is no monopoly on benefits which flow from hard work, from thrift or from savings and wise investments in production facilities. Such benefits accrue to other countries too whatever their national policy or philosophy, not to ours alone.

There are no short cuts, no substitutes for hard-earned progress. If we would maintain our position as the world's largest trading nation, would continue our economic advance and our social progress here at home, we must look to our laurels. We must match the initiative, the resourcefulness and efficiency of West Germany and Italy and the Netherlands as well as Japan and many other industrialized nations. We must match them both at home and in our huge markets abroad where there are no safeguards to protect us from competition.

This means that we too must work hard, perhaps harder. We too must be thrifty and must operate our national economic system sensibly on sound business principles. These things are essential if we would avoid pricing ourselves out of the world market.

Because of this problem some remedies are presently indicated. For example, we can ill afford at this time the fanciful manipulation of the national budget merely to

accommodate nonessential, politically attractive frills at the expense of our economy. During this period of national danger, with our defense burden alone far in excess of $40,000,000,000 annually, it would seem wise to economize on nonessentials at least and perhaps even to sacrifice in order to remain competitive and at the same time to meet the expenses of our own generation.

The second point we would make then is this. Difficult though our problem be we simply must not now abandon the historical American concepts which are inherent in our form of government and which are essential to our economic progress; the concepts of resourcefulness, personal responsibility and individual initiative and courage, coupled with imagination and self reliance. These are the concepts which have enabled us in the past to lead the world in production so that all could share and enjoy.

Just as these are the concepts which have made us strong and kept us free so also are they the concepts which hold the greatest promise for our continued economic welfare, our continued social advance and our spiritual satisfaction.

And now to the third and final point. Every American knows that the saddest shadow which darkens the face of the world is the threat of a nuclear war. It is ironical that with many nations virtually at each others throats people everywhere, in every land that we have visited yearn for peace, pray earnestly for its attainment, a peace in which there will be no need to devote a major share of the world's productive effort to the implements of death and destruction. The last point then has to do with the methods we believe should be employed in meeting our responsibilities as a people and as a nation in our search for lasting peace.

First we would like to dispel one illusion all too broadly held. Recently an outstanding military authority declared: "The best way to prevent war is for the United States and her allies to have such strong military forces that the Communists will not dare to start anything." We wholeheartedly disagree.

We firmly believe that adequate military strength is essential to guarantee national security. To prevent war, however, requires something apart from arms and defense alone.

Please be reminded that in our lifetime alone the United States has spent one trillion dollars, that is one thousand billion dollars, fighting one war after another and winning them only to be faced each time with the threat of a worse war, just as now. About all that seemingly has been accomplished is a switch in partners each time as we prepare for the next death dance.

Additional and perhaps new means to attain world peace simply must be discovered and applied with greater emphasis than ever before for time is running out and no one will win the next war if it comes.

This new effort toward peace must deal with the true causes of war, not merely with defense against potential enemies. It will not be enough in my judgment merely to plot our course as counter-moves against the Reds. We shall need a constructive program, a program of action and initiative.

We might begin it seems to me by making our purpose increasingly clear to all nations around the world. We must be better understood, be truly known for what we are, not just by what we say, much more by what we do.

Few of us realize how little really is known about us in countries around the world.

Nor will the mere dumping of millions or even billions of dollars overseas in any form of foreign aid in itself meet the purpose required. Aid funds must be accompanied by businesslike management and be administered under plans that make sense. No grants, for example, should ever by made when a repayable loan will serve. Nor should loans and grants be confused one with the other. If a loan is impractical, because of the inability of the recipient to pay, all parties are best served if this fact is recognized at the beginning and other means considered. Before concluding my remarks I wish to comment briefly concerning our relations specifically with the Russian Reds. They, of course are the principal source of the present trouble.

We believe it possible to build a road to peace even with Russia, not quickly and surely not easily, but it will take a great deal more than anti-Communist propaganda and hatred of the Russian people to do it. We are convinced that we must ultimately persuade the Russians to abandon their present objective to dominate the world in their own interest as well as ours or again we must fight.

Such persuasion will not be easy and it will take time, for it will involve communication not just with Khruschchev but with millions upon millions of people in various countries behind the Iron Curtain and elsewhere. We must earn the time required to accomplish this and we must improve our techniques and broaden our efforts toward communication as we use that time.

Furthermore, if persuasion is involved, as an old time salesman and a fairly good one, we have never made one sale yet through the mere use of fact and logic and argument alone. It is not enough merely to be right. The human equation also must be taken into account. No man can persuade with a chip on his shoulder and hatred in his heart.

Faced as we are just now with impulsiveness, instability and the truculent tone from the Soviet side, provocation is severe, but we simply must not merely respond in kind.

If we would gain our main objective we must neither be dismayed or distracted from our purpose by the intemperate antics of sorely harassed Red front men.

In our search for peace with justice, for the advance of freedom, what we shall need in our leaders during this decade is statesmanship of the highest order. We shall need competence, gained through experience, and patience, achieved through human understanding. We shall need integrity, proved courage and determination. We shall need in our new President justified self confidence, self confidence based upon adequate preparation and knowledge of world affairs. Any man given enough authority could through mere callous toughness, get us into war. It will take the best this nation can provide in qualified leadership to meet the crisis of this decade without war.

To provide such leadership and to sustain it requires essential public support. This is a challenge to all of the American people not just to the nation's leaders in Washington. It is essential that we, the American people make a clear distinction between mere belligerence and a firm national policy backed by solid strength. ▲

# THE STORY OF ATLANTIC CITY

by W. F. PRUDEN, Chief Engineer
Columbia-Geneva Steel Div., United States Steel Corp., San Francisco, Calif.

*. . . . agglomeration at high altitudes and in regions of severe winter weather introduces many process problems . . . . nevertheless, construction is now underway on an important source of high-grade agglomerate for Columbia-Geneva's blast furnaces . . . .*

ON June 30, 1960, ground was broken for the construction of the facilities to mine, concentrate and agglomerate the iron ores of the Atlantic City Wyoming area, which has become known as the Atlantic City project. When completed, the installation will be the first integrated iron ore beneficiation plant west of the Mississippi river producing an agglomerated product. The allocation of a large sum of money to a long term project of this type again illustrates the faith that the United States Steel Corp. has in the future potential of the western U. S.

This project, named for a nearby ghost mining town, is located in central Wyoming on the southeast flank of the Wind River Mountains. It is 16 miles north of the South Pass, where the early pioneers who followed the Mormon and Oregon Trails crossed the Continental Divide. White men first penetrated into this area in October, 1812, when the Robert Stuart party brought the returning Astorians through South Pass en route to St. Louis from the Columbia river area. Further interest in the area developed when gold was discovered in the sands of Rock Creek and the towns of Atlantic City and South Pass City were founded.

The Atlantic City ore body is about 28 miles south of Lander, Wyoming, and it is expected that the employees required for operating the new facility will live there. Lander is well equipped to handle the people who will operate the mine, for it has recently built a new hospital and a high school and has made plans for the healthy growth now expected.

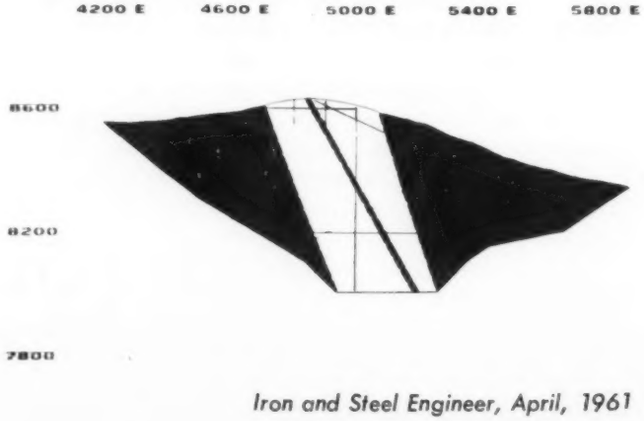
The beneficiated and agglomerated ore will move south over a 76-mile recently constructed railroad spur to connect with the Union Pacific Railroad at Winton Junction, approximately ten miles north of Rock Springs. From this connection the product will be hauled 279 miles to the blast furnaces at the Geneva works in Provo, Utah.

The ore body is a metamorphosed Pre-Cambrian sediment. The iron formation lies in a series of mica, sericite, chlorite, garnet and staurolite schists with abundant greenstones. All of the metamorphic rocks are intruded by small diorite dikes and sill-like bodies. Gently folded, east dipping Paleozoic sandstones and limestones cover the Pre-Cambrian rocks about a mile east of the exposed ore body. The deposit outcrops along a hill which tends northeasterly and, as is evident in Figure 1, dips about 85 degrees east. In the deepest drilling to date, termination at depth has not yet been determined.

The long range mining plan as developed provides for removing the ore by conventional methods using truck haulage on 25-ft levels with 37½-ft wide safety berms left on every third level. The average over-all pit slope will be 45 degrees.

Because the iron formation here is so similar to the

**Figure 1 — The ore body location, as illustrated by the cross-section view, made possible equipment locations which permit gravity flow operations.**



magnetic taconites in Minnesota as regards type and character of mineralization (it is difficult to distinguish if from the upper slaty member of the eastern Mesabi Range), it was possible to take advantage of the experience gained there in translating drill core test data to projected plant practice.

The core composites were all tested using the Oliver Iron Mining Div.'s standard methods for determination of magnetic iron content. In addition, representative composites were tested for concentratability and grindability.

In Figure 2, a typical concentration curve, is indicated the effect of grind upon the weight recovery of concentrate and the iron and silica content of that concentrate. As is common with typical magnetic taconites, the concentrate grade improves as the material is ground finer: at a grind of 70 per cent minus 270 mesh, the iron in the concentrate is 61.5 per cent; and at 90 per cent minus 270 mesh it is 65.5 per cent iron. Under the same conditions, the silica is lowered from 12 to 9 per cent with a corresponding reduction in the weight recovery from 39 to 35 per cent.

It became readily apparent as testing progressed that in the upper portion of the ore body, and especially on the eastern slope, that there was a definite halo of partial surface oxidation believed to be the result of melting snow from heavy drifts. Consequently, the ore was divided into two classes: prime and oxidized. Prime ore was defined as material having a concentration ratio of less than three to one and a total recovery of more than 75 per cent. Oxidized ore was defined as material having a concentration ratio of more than three to one and a total iron recovery of less than 75 per cent. Iron formation having a concentration ratio greater than five to one is considered waste.

As a result of these studies and because the upper ore must of necessity be taken first, the mining plan was divided into two phases: the first six years of operation wherein the major portion of the oxidized ore will be mined; and the remainder of the mine life, which will be in prime ore.

Late in 1956 preliminary engineering was started and it was decided to obtain a representative bulk sample of the ore body of sufficient size for full scale pilot plant testing; consequently, 3000 tons of ore were taken from a 728-ft adit which was cross driven across the ore body. This ore was shipped to the Pilotac plant of the Oliver Iron Mining Div. For control purposes, the ore was divided into two lots of 1500 tons each to check variations in ore types.

On the basis of the tests performed on the drill core composites, it was believed that a typical Minnesota taconite crushing and grinding flow sheet could be employed; hence, this ore was crushed, ground and concentrated in May, 1957, using commercial size equipment. As the result of this test, it was possible to obtain the data needed to firm up the design factors and at the same time assure management that the iron and silica content of the final shipped product would be as indicated by the concentratability tests on the drill cores. The concentrate produced in these tests was agglomerated by several different methods and further testing of the agglomerates was completed in a pilot plant blast furnace.

Upon completion of the full scale pilot plant tests,

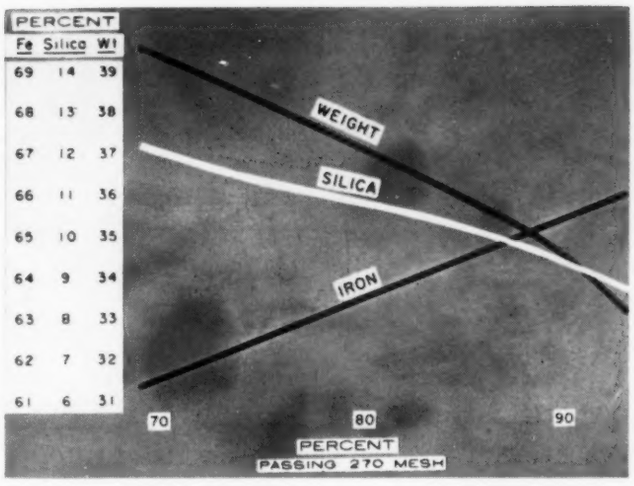



**Figure 2 — The iron content percentage of the concentrate is a function of the particle size.**

data was available to:

1. Develop the mining plan.
2. Determine the number of crushing stages required.
3. Fix the desired mesh-of-grind and determine the number of grinding steps and the types and sizes of mills required.
4. Outline magnetic concentrating and filtering characteristics and the equipment required.
5. Assist in the selection of the agglomerating method to be used.

In addition to the many characteristics of the ore and its processing, there were several location and climate considerations which had a definite influence upon layout, design and the methods used in handling the material in process.

The weather at Atlantic City is similar to that encountered in northern Minnesota, except for the amount of precipitation; hence, it was apparent that one could expect hard freezing conditions from November to May. Because of the necessity to reclaim and reuse all water possible, and the known deleterious effects of calcium on the balling characteristics of concentrates, the addition of calcium chloride to the ore to inhibit freezing had to be ruled out. To assist in the prevention of frozen ore in crushing plant bins, the final crushing flow sheet and layout provides for the removal of all ore fines as soon as they are made, these are then added back with the crushed ore prior to storage ahead of the primary grinding mills.

Because of the long periods of inclement weather, all processing buildings will be insulated and all working areas heated.

Water is a major factor of concern to all ore dressing operations, and in this arid section of the West it is of particular importance. As a result the use of fresh water must be maintained at a minimum and complete facilities installed to recover to the maximum extent possible all of the water after process use.

Water runoff data for Rock Creek, the principal source of water, indicated that 50 per cent of the available water is produced from melting snow that runs off during the month of May. In order to supply the plant fresh water and process makeup water, which

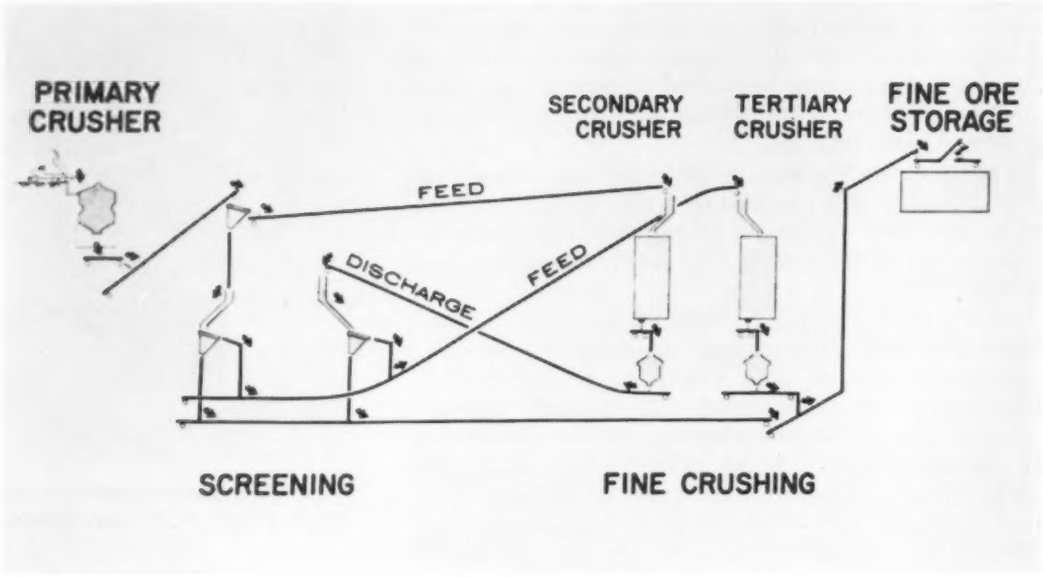



**Figure 3 — Crushing of the ore will be done in three crushers to a minus ¾-in. size.**

will average about 2000 gpm, a 2800-acre ft reservoir was designed for impounding this water during the spring runoff for use during the remainder of the year. Such a storage would have sufficiency in the worst 3-year drought cycle during the past 50 years.

The plant is located at an average elevation of 8300 ft above sea level. This introduces many processing problems. The effect of this altitude is better understood when one considers that the air is only 75 per cent as dense as at sea level and water boils at 196 F. As a result it was necessary to derate all air-cooled equipment such as electrical motors. Since the maximum attainable vacuum at this elevation is only 21 in. of mercury rather than the 30 in. at sea level, it was necessary to install filter area twice that required in a plant at sea level. All internal combustion equipment such as trucks and railroad locomotives had to be specified to deliver the desired horsepower at this elevation.

The effect of the thinner air on the agglomerating operation was especially acute. It was necessary to increase the length of the machine by approximately 15 per cent and increase the fan sizes by 20 per cent. Since additional energy is consumed by these modifications, the kwhr requirements per ton of product had to be appropriately adjusted over the amount used in a sea level plant.

Considerable wind and drifting snow are the normal winter conditions; consequently, all buildings were designed with flat roofs and alined with the prevailing wind to assist in self-cleaning and the prevention of build-ups of snow and ice and the safety hazards that result from slides. Precast concrete panels are installed along the lower six ft on the sides of all buildings as protection to the sandwich siding from show removal equipment. Much attention has been given to prevention of moisture penetration at the outside walls of all buildings.

As shown in the schematic flow sheet (Figure 3) the as-mined ore will be crushed in a 54-in. gyratory crusher with a closed side setting of six in. This product will be screened into a plus 1½ in. and a minus 1½-in. fractions. The minus 1½-in. portion will be further screened to remove the minus ¾-in. material. The plus 1½-in. portion will be crushed in a second stage in two 7-ft standard cone crushers and then screened to remove the minus ¾-in. material. The combined plus ¾-in. oversize from the two screens will be put through the third-stage crushers, two 7-ft short head cone crushers whose product will be combined with the fines from the other screening operations and conveyed to the rod mill feed storage bins.

The concentrator will consist of three milling circuits operating in parallel. Each circuit will consist of one 10.5 x 15-ft rod mill for primary grinding followed by two 10.5 x 15-ft ball mills with the subsidiary magnetic separators, classification and filtering units.

In the concentrator (Figure 4) the ¾-in. ore is ground by the rod mills and then magnetically separated by the cobbers. The ball mill grinding is in closed circuit with rougher magnetic separators and cyclone classifiers. After grinding the pulp is deslimed and passed through the third stage magnetic separators: the finishers. Thickening and filtering complete the operation.

Because of the filtering problem at this elevation and the need for uniformity in the filter cake moisture if good pellets are to result, a system was designed to provide a storage for 36 hr of feed to the pelletizing plant. Figure 5 illustrates this storage system which will stabilize the balling operation and assist in obtaining a uniform product. This plant will have two separate processing units operating in parallel each with three balling drums and one 6-ft wide, 32-wind box pelletizing machine.

After blending the filter cake will be fed to a balling drum operating in closed circuit with screens. When a green ball is of a sufficient size, approximately ½ in., it will leave the circuit and pass to the pelletizing machine. On this machine, the green balls will be dried, heated to approximately 2400 F and then cooled prior to discharge.

In the design of all portions of this project, considerable use has been made of models. These models were of particular importance in the studies leading toward the actual operation of the plant. It is believed that a model does:

1. Permits 3-dimensional comprehensions of the complexities of the plant that could not be obtained

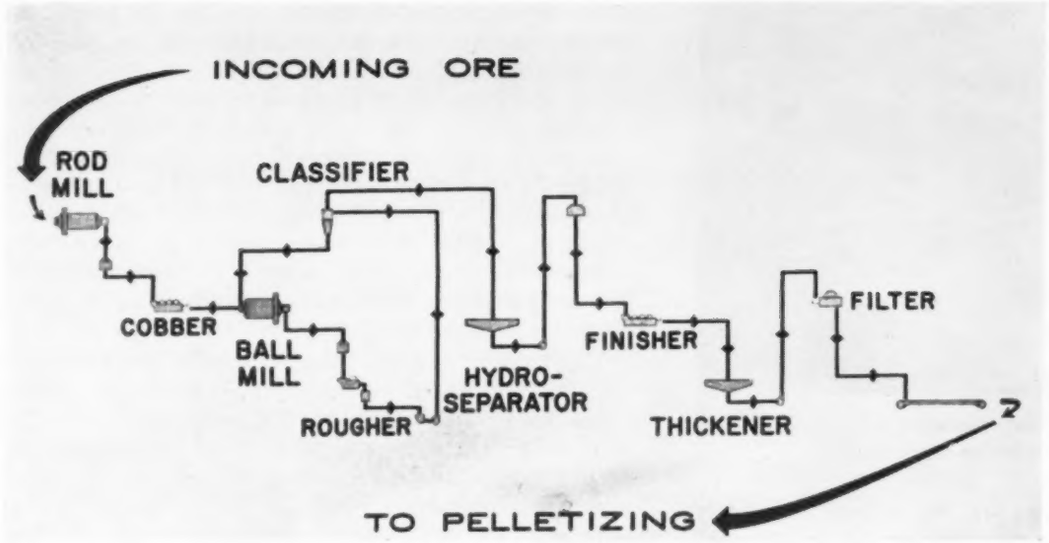



**Figure 4 — Concentration of the sized ore is accomplished by three milling circuits operating in parallel.**

without tedious review of the blueprints. This is particularly applicable to operations.

2. Assists in the study of the problems of maintenance in and around all equipment.

3. Provides for a detailed study of the operations and operator locations which could be reviewed on the models and results compared to actual job site studies obtained at the time of design.

4. Helps to solve many problems in material flow and equipment design prior to actual startup.

In addition the models have been moved to the construction site to assist in scheduling and coordination of that phase of the work. They will also be used to help train operators and finally to explain layouts to visitors.

Public utilities in this area were of prime importance in the general plant layout since electrical power and fuel costs are major factors in an operation of this type. Electrical energy will come from the Pacific Power and Light Co.'s new facilities at Glenrock, Wyoming, and in addition an emergency diesel-electric generating plant will be maintained at the plant site. This unit is large enough to supply essential services and allow the equipment handling hot materials, such as the pelletizing fans, to be cooled without harm if the main source of power is lost. Natural gas will be supplied by the Northern Mountain Gas Co. of Casper, Wyoming, through a pipe line about 25 miles long from the Beaver Field east of Lander, Wyoming.

The model of the plant area (Figure 6) shows a 3-dimensional layout of the principal operating departments. The primary crusher located at the upper right hand corner is at the center of gravity of the ore body. That is, 50 per cent of the ore will be raised by conveyor to the screen house. The ore is conveyed uphill, through the fine crushing plant and into the fine ore storage bins ahead of the rod mills.

The lay of the ground made it possible to locate the concentrator on the side of a hill for gravity flow of ore and pulp through the process. This plant is at the lower left section of the slide. In addition this plant location will provide for the discharge of tailings both coarse and fine directly to the tailings basin. By building a trestle across the tailings basin, fine tailings

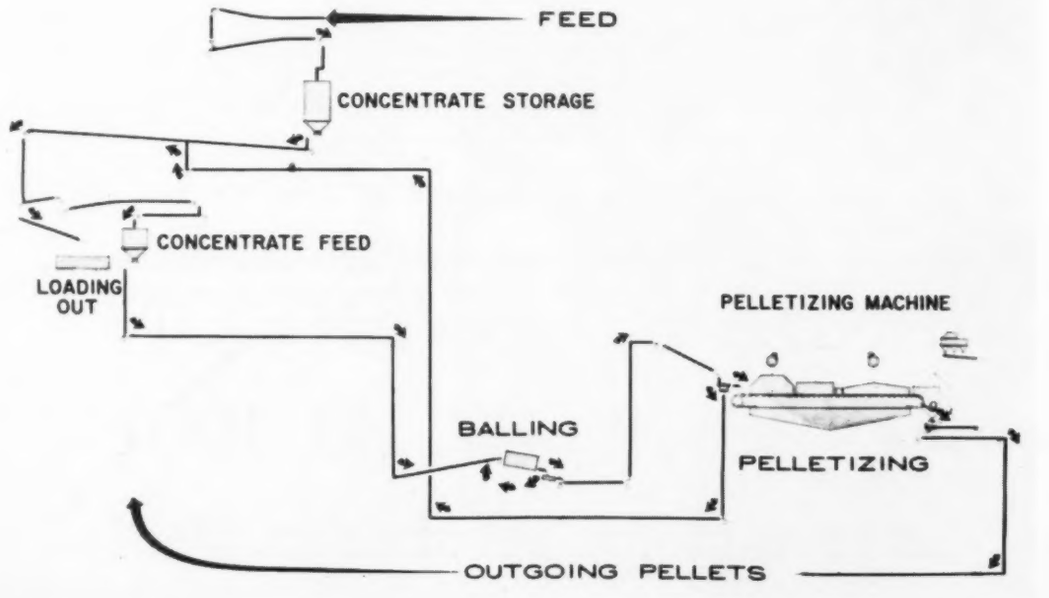



**Figure 5 — Concentrated ore is blended, balled to ½-in. size and baked at 2400 F.**

**Figure 6 — A 3-dimensional model of the plant layout aided in over-all plant preconstruction studies.**

can be disposed of by gravity for at least ten years without pumping. The coarse tailings will be disposed of by truck directly across the plant road into an area with sufficient volume for the life of the property.

The concentrate, as filter cake, will be conveyed to a higher level area which offered the only suitable site for the pelletizing operation and the related loadout facilities and railroad yards. Location of this portion of the plant was also influenced by the layout of the railroad and the entrance of the railroad spur to the facility.

A 2½-mile long overflow ditch will extend from the reservoir on Rock Creek to the Slate Creek drainage, which in turn will return the water to Rock Creek. Fresh water for the plant is handled by a 20-in. line with gravity flow to the main pump house located near the concentrator. After thickening fine tailings are transported through a gravity pipe line to the South Dam. The line to the North Dam is also by gravity in the early years. Return water from the tailings basin is settled after decantation and returned to the concentrator over the tailings trestle. Except during emergency, no water will be discharged from the tailings basin into the Rock Creek flowage.

Much effort has been devoted to the control of dust and fumes throughout the project. Each building has been considered as a separate problem in ventilation and adequate air changes have been incorporated to produce a clean and cool working area. Wherever air is withdrawn from a building area, adequate provision has been made for this volume to be brought into the building under controlled conditions. In all blind areas, air will be moved under positive control.

Many types of dust collectors have been selected for the plant; however, wet collectors and bag collectors have been specified wherever possible to avoid the discharge of dust into the atmosphere. In no case will the collectors exhaust into a building area. The individual systems will be balanced to achieve the proper carrying velocity. All ducts will have blast gates for final velocity balance which will be made in the field.

All sources of dust have been analyzed and provision made to prevent any discharge into a working area. Removal of dust alone is not sufficient. In all cases adequate air is supplied to each exhaust system to prevent a pressure drop in the area from hindering the operation of the fans.

The facility will be equipped with a central maintenance shop which will be operated on a 24-hr, 7-day schedule. In this shop, all the equipment necessary to maintain the plant will be installed. Each operating area is equipped with a maintenance section from which assigned maintenance crews will work.

In addition to the design of a mine, crushing plant concentrator and pelletizing plant, it was necessary to consider how the product would be handled through the ore storage yards to the blast furnaces at the Columbia-Geneva blast furnaces at Provo. Although the plant is adequately supplied with unloading, screening and blending facilities for the present ore shipments from Southern Utah, they were not considered to be entirely suitable or adequate for the pellets from Atlantic City.

Various plans to handle and store these new agglomerates were considered. It was concluded that a system was needed to provide the furnaces with long runs of burden constituents which would be uniform in both physical and chemical composition. The final design allows for wet screening of the agglomerates and an adequate surge pile to allow blending over a 2-week period. The surge pile will be built by tripper belt and the pellets reclaimed by rotary reclaimers. Suitable by-pass arrangements are designed so that the pellets can go directly to the furnace bins.

To complete a job of this magnitude within 24 months in this location and with the weather prevailing, seasonal factors must be recognized in the construction schedule. It is essential that all structures be enclosed by November 1, 1961, so that process machinery installation can be completed during the winter of 1961–1962 to permit completion and initial production in the last half of 1962.

In summary, the engineering has been completed, the construction is underway and Columbia-Geneva now looks forward to an operating facility which will produce a high-grade agglomerate for the Geneva blast furnaces. ▲


AISE ANNUAL CONVENTION

September 25, 26, 27, 28, 1961

Penn-Sheraton Hotel, Pittsburgh, Pa.

# Bethlehem's Steelton Plant Undergoes Further Diversification

FULL production runs at the new reinforcing bar mill and bar fabricating shop at Bethlehem Steel Co.'s Steelton plant have begun.

Annual capacity of the new mill is 350,000 tons of reinforcing bars in sizes from No. 3 to 11, inclusive. Bars are of the so-called deformed concrete reinforcing type.

Under construction for over a year, the new mill is housed in three new buildings: one structure, 106 x 330 ft, contains the heating furnace and mill proper; the second, 391-ft long, is arranged crosswise to the long mill building and houses the shears and shipping facilities; and the third, 70 x 360 ft, is the cooling bed building at the end and in line with the main mill building. The rebar fabricating shop is connected and constructed at right angles to the finished product shipping and storage area.

The new mill is of the continuous type, 2-strand, with 17 stands, and two looping stands (repeaters). A modern oil-fired continuous heating furnace is installed ahead of the mill for heating 4 x 4 in. by 40-ft long billets, supplied by the Steelton rail mill. Two hot beds with shearing facilities at the discharge end complete the main facilities. The layout of the mill permits the future addition of finishing stands and coilers for the production of rods as well as reinforcing bars.

Production of rebars in this fully automatic mill is fast, high quality and versatile.

The mill can produce, for example, about a mile of No. 3 (3/8-in. diameter) rebars from one 4 x 4 in. by 40-ft long billet with the bar moving to the cooling beds at a rate of 2600 fpm. Double stranding permits the manufacture of over 5200 60-ft lengths of No. 3 bars per hr. A 5-ton bundle of No. 3 rods can be shipped every 10½ min; the larger, heavier bars can be bundled and shipped even faster. For example, No. 11 size, which requires only 32 rods per 5-ton bundle, can be loaded out in less than five min per bundle.

The modern, fully automatic mill, controlled by instant-acting electronic devices, leaves little chance for human error; only new open hearth billet steel is fed into the mill.

Changeover from any one bar size to another requires only the adding or subtracting of roughing and finishing stands. Special cut-offs permit the production of small amounts of special sizes without undue interruption of big production runs.

## PROCEDURE

Billets measuring 4 x 4 in. by 40 ft long and weighing about one ton each are stockpiled in a 40,000-ton storage area. Steel pipe posts in the storage area separate billets into sections according to various heats and grades.

A 25-ton magnet crane picks up as many as 18 billets at a time and feeds them into a rack of billet separating skids. As two billets at a time tumble by gravity feed onto the powered rollers of a billet charging table, a billet discard unit flips out any billets not suitable for charging into the furnace.

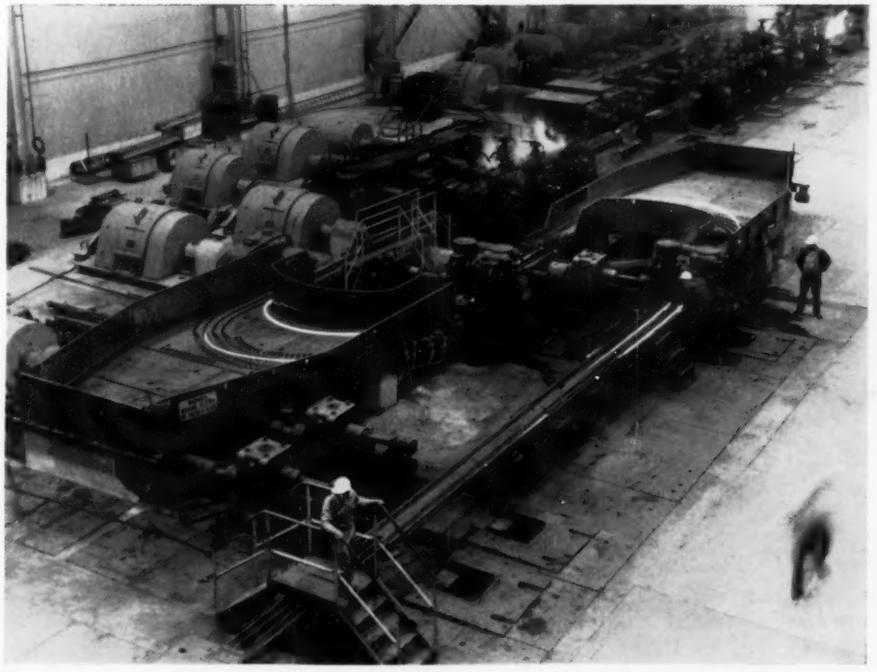
A furnace ram charger then shoves the billet into the side of the 2-zone, oil-fired furnace. Actuated by a furnace cross pusher, the billets then move laterally down hearth through the 17-burner sloping heating zone and into the 21-burner soak zone. Temperature in the heating zone is approximately 2150 F; in the soak zone the temperature is 2270 F.

The furnace rated at 100 tons per hr, can accommodate 165 billets at any one time. A typical billet completes its run through the furnace in about 105 min.

Thus far all operations picking and sorting of billets, charging them into the furnace and moving them down the sloping hearth, are handled by one man in a glass-enclosed control booth manipulating short-throw levers. He charges another pair of billets into the furnace when a signal is received from the man who actuates the furnace push-out at the discharge end of the furnace. When double stranding for No. 3 to No. 6 bars is being performed, two billets are fed simultaneously into the roughing stands. For No. 7 to No. 11 sizes, single stranding is employed, and only one billet is fed at a time. The push-out man feeds hot billets according to word from the operator at the cooling beds who informs him that the line is clear.

A pull-out and switch plate at the discharge end of the furnace feeds

**Figure 1 — The 2-stand mill can roll 4 x 4-in. billets into 3/8-in. rod at 2600 fpm.**



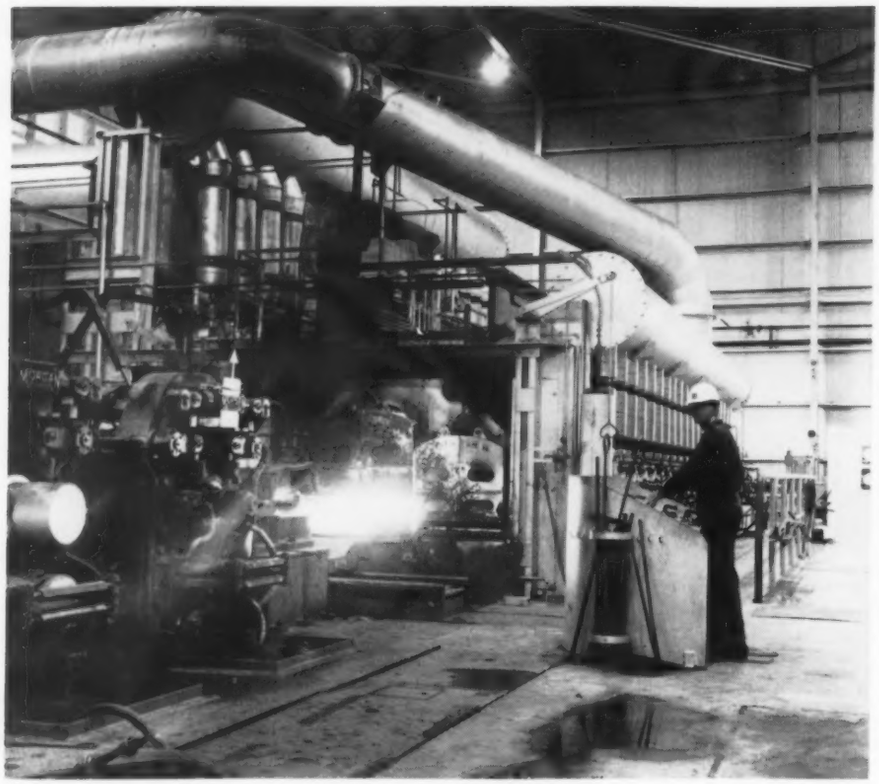


**Figure 2 — The reheat furnace, rated at 100 tons per hr, heats the billets to 2270 F.**

the red-hot billets either to a toggle shear if special items are being produced or directly to the 9-stand roughing mill if standard rebars are being made.

The 4 x 4-in. billet emerges from the roughing mill either as a 1-in. or a 2-in. sq, depending upon what size bar is being formed. Next, two crop and cobble shears cut the cold front end off the bar (about an in. or so). These shears can also quickly cut the product to scrap pan sizes to eliminate cobble and readily get it out of the line. The bar next passes through a 4-stand intermediate mill, and emerges as either a $^{9}/_{16}$-in. sq or a $1^{3}/_{4}$-in. round.

For making No. 5 to No. 11 bar sizes, the $1^{3}/_{4}$-in. round passes through the No. 14 stand and emerges as a "round-edge flat" and then receives its deformations and is finished to size in the No. 15 stand.

For making No. 3 and No. 4 rebars, the $^{9}/_{16}$-in. sq bar is further reduced through No. 14, 15 and 16 stands and then receives its deformations in finishing stand No. 17. Thus, the mill uses between 9 and 17 stands to produce the various rebar sizes.

Two repeaters or looping stands are located in the line, one between No. 13 and 14 stands and one between No. 14 and No. 15 stands. Here, large steel pans allow the bar to flex and flare out should there be any difference in relative speed at the leading or trailing end of the bar (which could be up to a mile long for the smallest size). The repeaters are equipped with kick-outs and snap shears. These safeguards kick the bar out of the grooved track to prevent kinks and cut off the product flow should there be any trouble in the line.

A tachometer on the finishing stand (No. 15 or 17, depending upon the bar size) measures the length of the finished product. This electronic counting device sends signals to the rotary drum dividing shear, located just ahead of the cooling beds, to automatically cut the bar into desired cooling bed lengths (generally multiples of 60 ft). The shear can also be operated manually to produce special bar lengths.

The bars, now down to finished size and semi-finished length, are moved onto the center of the 270-ft long cooling beds by run-out table rolls, driven by individual motors.

A paddle wheel kick-off device, actuated automatically by preselected insulated rolls, flips the long bar laterally onto the first of 37 notches on either side of the cooling bed. As each successive bar moves onto the bed, a carryover unit deposits the preceding bars into the next notch laterally.

When double stranding both sides of the cooling bed are employed simultaneously. When single stranding (No. 7 through No. 11 bars), the product goes to alternate sides of the bed with each successive billet.

After the bar has completed its notch-by-notch movement across the width of the cooling bed, it is ready for cutting to desired length. Temperature of the bars is about 500 F. The bars are accumulated into groups (about 66 No. 3 bars down to 16 No. 11 bars) for cutting by two Q-bar shears, one located on each side of the bed. The number of bars is varied according to size to maintain the same volume of steel being cut, as determined by the actual capacity of the shear. Alining rolls on the cooling bed bring the bars evenly to the Q-shear.

Normally, the Q-bar shears cut to 60-ft standard length, but of course bars can be precision cut to meet special job specifications. Next, the rebars are bundled into 5-ton lots for shipment. Because the two smallest sizes of rebars require a large number to make up a 5-ton bundle, these rods are first tied into 20 and 15-bar sub-bundles. Then several sub-bundles are bound together to form the standard 5-ton lift.

In back of the shear table, bar handling equipment, using chain transfers and accessories, discharges the sub-bundles into a cradle semi-automatically to make up 5-ton bundles. Also provision is made for handling bars shorter than standard lengths mechanically instead of by hand.

A 10-ton overhead magnet crane then picks up the bundles, each tied with 12-gage wire, one at a time and transports them to the storage area or directly onto rail cars for shipment.

### REINFORCING BAR FABRICATING SHOP

Built adjacent to the product storage area, Bethlehem's new reinforcing bar fabricating shop can cut, bend, bundle and tag as required for immediate field installation by the contractor. The shop is equipped with a stirrup bender, two shears for reshearing to desired length, and three bar benders. ▲

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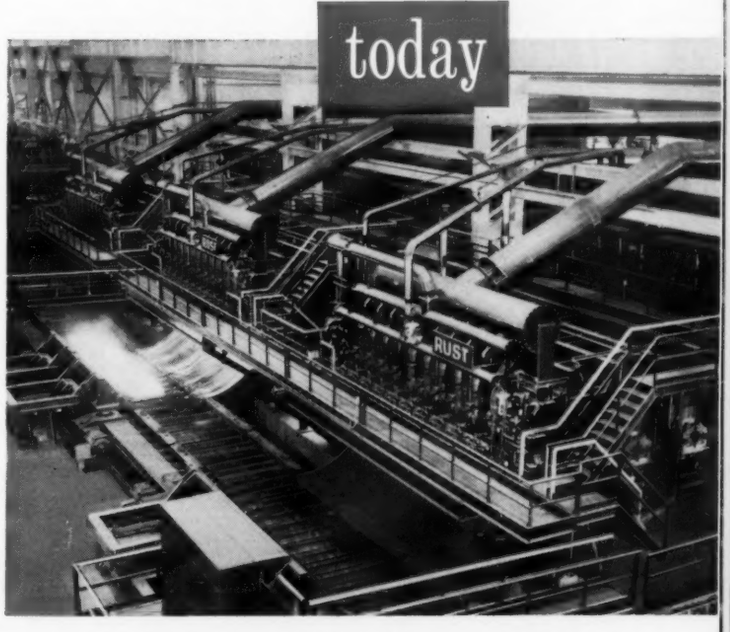


Modern three-zone, continuous furnace now reheating slabs for Kaiser Steel Corp. 86" Hot Strip Mill, Fontana, Calif.

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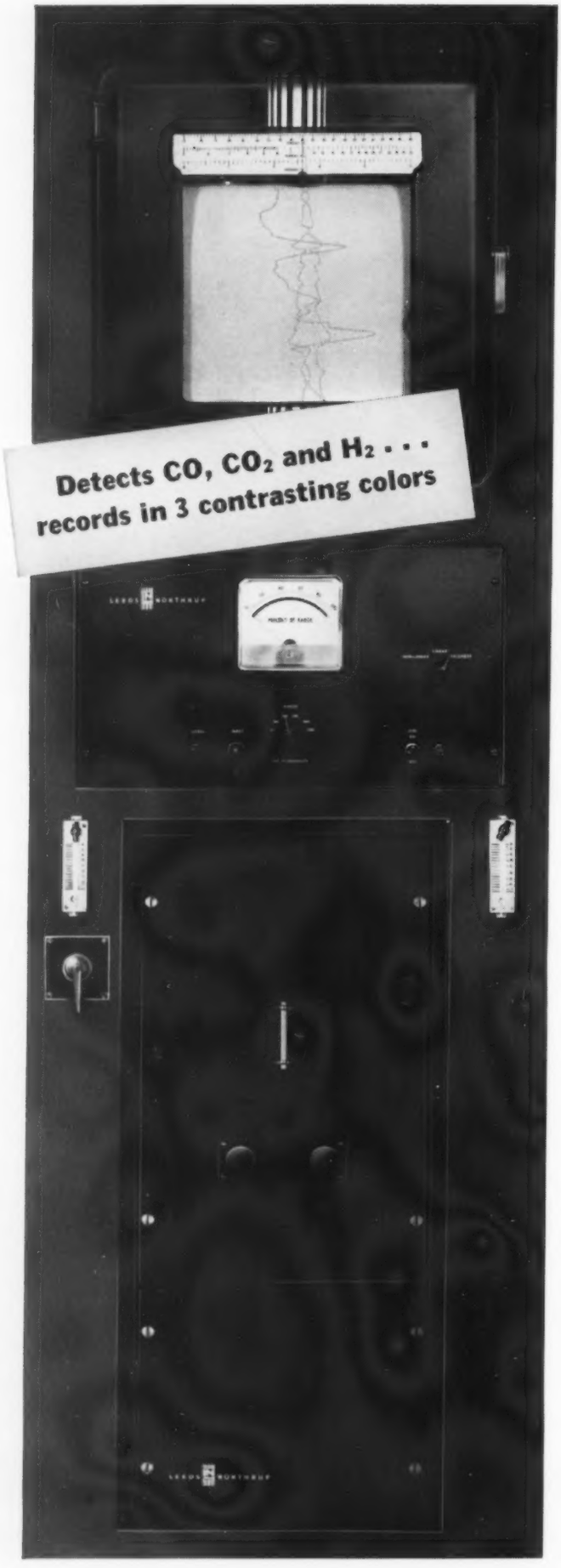


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# Japanese Steel Capacity To Double by 1970

A NEW study of production plans of Japan's "big six" steel companies reveals that they expect to double their present output in the next five years.

That fact was revealed in the most comprehensive report of Japan's steel industry yet produced, issued by The Fuji Bank.

The analysis of Japan's steel industry also made these points:

While the U. S. steel industry in 1960 operated at well below capacity, Japanese 1960 steel production rose to over 25 million net tons placing Japan fifth among the world's producers.

Steel produced in Japan last year exceeded French production by 6.6 million net tons and nearly equaled that of the United Kingdom.

A study of production plans of the "big six" companies, which produce 92 per cent of Japan's pig iron and 68 per cent of its crude steel, indicates that they will achieve the Ikeda Government's 10-year plan for production of 48 million tons of crude steel annually by 1970, five years ahead of schedule.

If this production target is achieved, however, it is somewhat doubtful that demand will expand rapidly enough to catch up with such rapid growth, thus posing new problems.

Principal factors favoring continued expansion of the Japanese steel industry are the low per capita steel consumption rates, lack of competition in Japan's main export market of Southeast Asia, and the immense potential market of mainland China. Regarding domestic consumption, Japan's producers hope to raise it by 1970 or earlier to the present U. S. figures of 960 lb per person.

Because Japan lacks domestic raw materials, 73 per cent of its iron ore, 45 per cent of the coking coal and 53 per cent of scrap must be imported, the industry has developed new techniques, locating steel mills along the seacoast. There bulk carriers discharge iron ore and coal cargoes onto conveyor systems running directly to plants.

Despite the need to import raw materials, production costs in the 1957–58 period, while higher than the U. S., were equal to those in Germany and in England and appreciably lower than France.

Low wages, while an important part of the cost picture, are somewhat offset by lower productivity of Japanese mills. But as productivity rises, the wage differential is expected to remain fairly constant. Japan expects to maintain her advantage in this regard for a considerable period.

Faced with high interest rates and domestic capital shortages, the major steel companies have been obliged to seek capital requirements outside Japan. The "big six," Yawata Iron and Steel Co., Ltd., Fuji Iron and Steel Co., Ltd., Nippon Steel Tube Co., Ltd., Kawasaki Steel Corp., Sumitomo Metal Industries, Ltd., and Kobe Steel Works, Ltd. have received a total of $57,900,000 in loans from the World Bank. Kawasaki and Sumitomo have floated bonds on the American market, and Kobe Steel recently borrowed $30,000,000 from Prudential Life Insurance Co.

Despite heavy reliance on borrowed capital with resultant lower net worth and liquidity, the growth potential and relative stability of the Japanese steel industry make it highly attractive to foreign investors.

In terms of sales volume, Yawata ranked first, Fuji third and Nippon fifth among Japan's top ten manufacturers. Internationally, according to *Fortune Magazine's* 1960 compilation, Yawata was 28th, Fuji 53rd and Nippon 59th among the hundred largest non-U. S. industrial concerns. ▲


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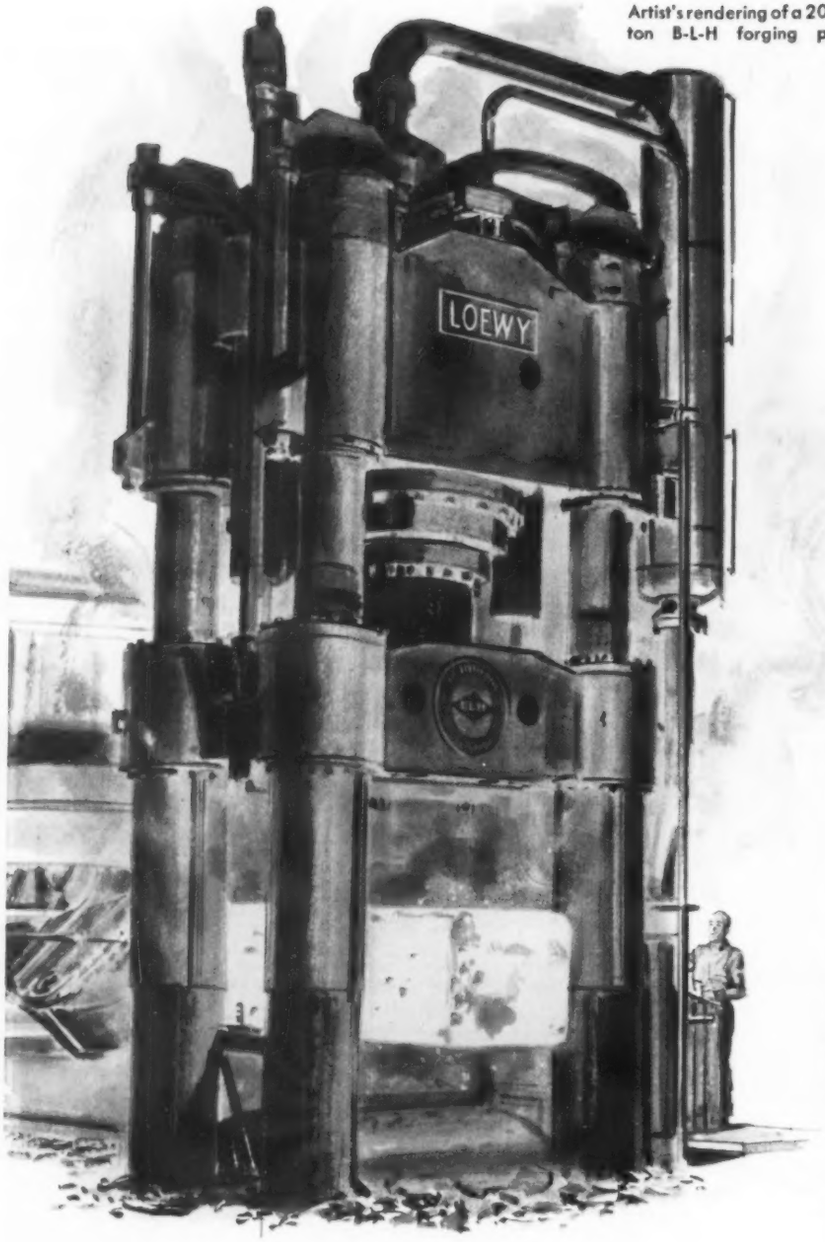


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# Dust Suppression Improves Operation and Industrial Relations

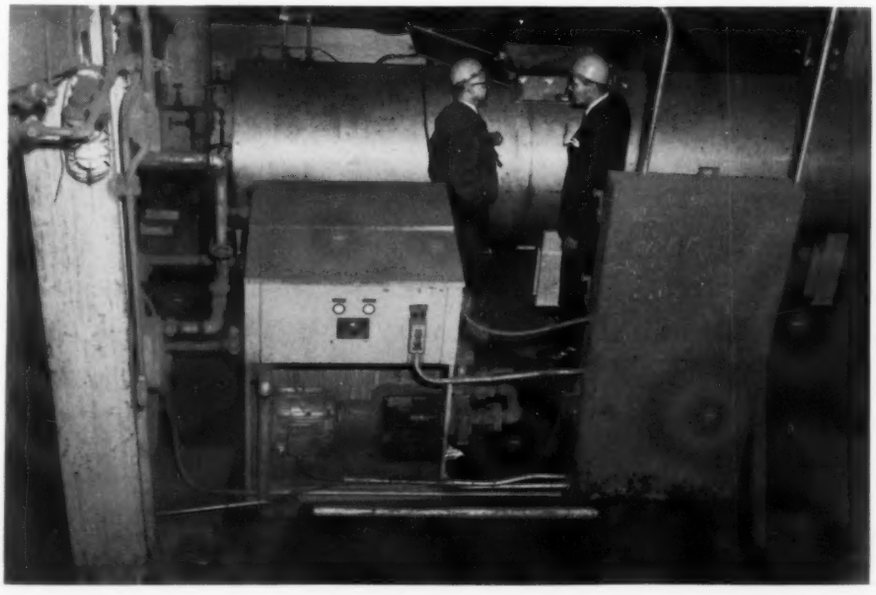
INLAND Steel Co. solved several production problems by installing an ore sintering plant at its Indiana Harbor works. However, to forestall the creation of an industrial relations problem due to dust, engineers and production men, working with dust control engineers of The Johnson-March Corp., developed and installed the first full scale dust suppression system for an iron ore sintering plant.

The system is similar to dust suppression systems widely used to control dust in coke plants, power plants, coal mining, quarrying, cement manufacturing, etc. The basic system, called a Chem-Jet system, is modified to counteract the unique problems involved in suppressing sinter dust.

To suppress dust, the fine particles that rise into the air must be wetted whether the fines are coal dust, cement dust, or iron ore sinter dust. Generally, fines cannot be wetted by the application of raw water. In fact most fines will float on water for many hours and some times even days supported by the water's surface tension. The Inland dust suppression system utilizes a surface active chemical concentrate, called Compound MR, to reduce the surface tension and make the water wet quickly. If the particles are not wetted rapidly, the moisture will be driven off before any dust is suppressed. Inland's dust suppression system depends on two things. First, the water must be properly treated. Second, the resultant solution must be applied in precisely the right amount and at certain key locations.

**Figure 2 — The solution is sprayed on the material at points of dust generation.**

**Figure 1 — The wetting agent is mixed with water in a ratio of 1000 to 1.**



It was more difficult to determine the precise amount of solution to apply at Inland than in any previous Chem-Jet installation. In treating coal or limestone, the effect of the Compound MR solution will carry over many transfer points as long as the material is not recrushed to expose new surfaces. For example, in a power plant, one or two treatment points are sufficient to suppress dust all the way from a crusher to a bunker.

Heat was a major factor in designing Inland's dust suppression system. In handling sinter, the heat of the product coming off the table can be as high as 600 to 700 F. There was some question of the practicality of treating materials at this temperature with a water solution. Much of the solution could vaporize before doing any good. Actually, the product coming off the sinter table is nonhomogeneous, and is made up of various size particles from the fines of 15 to 20 microns to large clinkers weighing several lb.

**Figure 3 — Spray can be controlled automatically.**

The temperature of any individual part varies with its mass. Large pieces can be cherry red coming off the table. The larger the mass, the greater the heat content. On the other hand, the temperature of the fines ranges from 125 to 150 F and it is these small, low temperature particles that require treatment. Obviously, the large clinkers will not become air-borne and create dust. Therefore, the problem was to wet the fine particles thoroughly in order to attain effective dust control.

The Chem-Jet dust control system was designed to first treat the sinter coming out of the cooler with plain water. The purpose of this initial application was to cool the sinter fines and prepare the sinter for subsequent treatment. Then the sinter is treated with a very small quantity of the wetting compound at every conveyor transfer point through carefully located spray jets. It is important to utilize spray jets of the proper capacity and spray pattern to suppress the dust without wetting the belts and the surrounding area.

Although the heat of the process does not reduce the effectiveness of the dust suppression system, it does reduce the carry-over distance. Normally, approximately 0.5 per cent of moisture is sufficient to suppress dust in most process materials. This amount is also sufficient for Inland's sintering operation. However, to retain this moisture content on the average, as much as 0.7 per cent is added. As the product travels along the conveyors the moisture evaporates. Sprays, located at various points in the system, provide small booster applications to re-establish the desired moisture content.

Inland stores Compound MR, the surface active concentrate, in an 1160 gal stainless steel tank. The compound is drawn from this tank and mixed with water in a ratio of 1000 parts of water to one part of MR in the a Chem-Jet proportioner as shown in Figure 1. Water is supplied by line pressure and the compound is metered by a bellows type positive displacement pump into the mixing tank. A 75-gpm centrifugal pump distributes the chemical solution to the various spray points.

Solution is applied as shown in Figure 2, at points of greatest turbulence which would, naturally, generate the most dust. Each spray header is individually adjustable to regulate the amount of moisture applied at any particular point. This is particularly important since the major turbulence points are at the end of conveyors. The amount of moisture the product loses varies considerably from spray point to spray point since the conveyors are of different lengths. Automatic spray controls (Figure 3) are utilized to sense the load on the belt and turn the sprays off automatically when there is no product on the belt.

The dust control system was designed to encompass all conveyors, transfer points, loading points, chutes, bins, etc., handling sinter from the cooler, sinter product, sinter fines and hearth layer at conveyor loads ranging from 50 to 360 tons per hr.

Screening operations are the major source of dust generation. There are eight conveyor loading points in addition to discharge of sinter into the top of the screens. Four separate conveyors are loaded with large product, hearth layer material, intermediate product and, finally, sinter fines. No sprays are necessary at any of the product conveyor loading chutes as the effect of the spray at the entrance to the screens suppresses dust all the way through the screening operations on the entire length of the various product conveyors. However, additional sprays are applied to the sinter fines as it is discharged to the conveyor that transfers it to the sinter fines storage bin.

The effect of these sprays can be best illustrated by Figures 4 and 5. Figure 4 was taken with the process in full operation. The system was turned off for demonstration purposes, and it was necessary to wait 30 to 40 min until sinter sprayed at the sinter cooler cleared the screen house. Figure 5 was taken with the system turned off.

The quality of Inland's sinter and the effectiveness of the dust control system are tied closely together. The dust control engineers found that good sinter is vital to have the system work most effectively. There must be good quality control on the mix. This is important since the sintering operation is running at a constant speed. If the machine is run too fast or too much coke is added, unburned product would come off the end of the sintering table. This mix would enter the cooler and sinter would be made in the cooler. The cooler discharge would then be too hot to treat practically.

Probably the best indication of the effectiveness of the dust suppression system can be seen from outside the sintering operation. Prior

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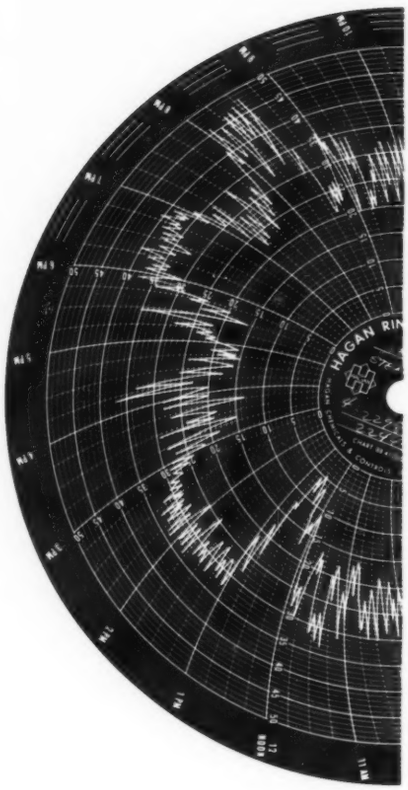
Wide Flange Beam and Structural Mill at the South Works of the United States Steel Corporation

# How to take the WASTE out of WASTE HEAT



The installation of precipitators as part of an air pollution control program need *not* be all outgo and no income. Since waste gases *must* be cooled before entering the precipitators, the use of waste heat boilers to achieve the cooling can lower long-term costs sharply.

However, the economical advantages of waste heat utilization have been bypassed in some plants because no good solution to several chronic waste heat boiler problems was then available. The worst of these problems were:

1. Steam production was not steady enough to be relied on for either process or power loads.
2. Boiler maintenance costs were high due to the rapid and wide fluctuations in available heat.

Now Hagan provides solutions to these and other problems by a series of systems designed to make waste heat boiler operation efficient and reliable. Let's take a look at how Hagan Automatic Control can be applied in a variety of situations:

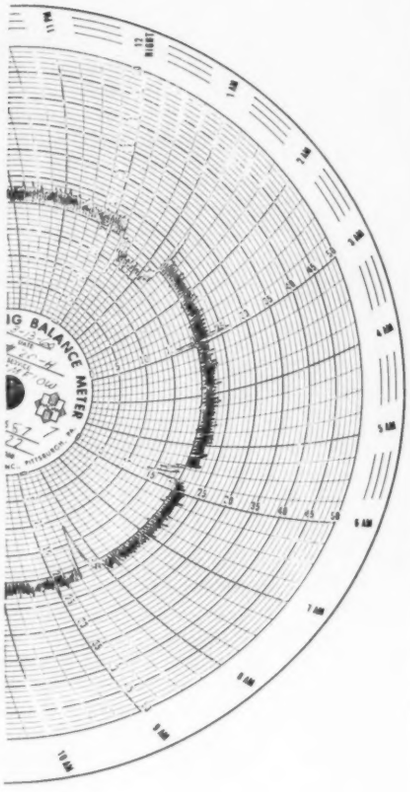
In an existing installation in a Midwest steel mill, plant steam demand constantly overloaded the waste heat boilers. Increases in open hearth capacity since 1948 caused boiler loads to jump to 100% in excess of rating. Result—feedwater problems, tube failures, safety valve wear, criticism by the insurance company and generally excessive maintenance costs.

The solution here, as in other cases where boiler capacity is limited, was in the installation of Hagan Automatic Boiler Load Control. The charts above illustrate the before and after conditions. Boilers are safeguarded, maintenance costs are way down and furnace pressure control is unaffected.

Next, take the case of the plant where boiler *capacity* is adequate for the peaks, but steam requirements remain constant, so it is necessary to fill in the valleys. Here Hagan's long experience with multiple fuel firing takes over. The solution is the use of an auxiliary fuel, under completely automatic control, to maintain steam production constant at the rated capacity of the boiler. Now, the economies of waste heat utilization can be realized completely.

Finally, there is the situation where neither of the above solutions is applicable. In this case, the most critical control area is maintaining drum level. The usual one-element, or even three-element, systems have not been equal to boiler conditions caused by sudden large swings in steaming rates. Carry-over and boiler damage are the inevitable result. The Hagan solution incorporates the use of drum level programming combined with an unusual application of the rate of load change function to deal properly with this problem.

These methods of making waste heat perform reliably are useful in existing plants, and should certainly be made a part of new plant design. A Hagan engineer, well versed in steel mill problems, will be glad to relate Hagan experience to the needs of your operation. Write or phone:



(Above—left) Steam flow chart on a waste heat boiler before the application of Hagan Automatic Load Control. Note the tremendous swings in steaming rate, from a low of 8 to a high of 48. At times, the boiler was producing more steam than there was feedwater available. Maintenance and labor costs soared.

(Above—right) Steam flow chart after Automatic Load Control was installed. The system is a part of the over-all open-hearth furnace control system, and safeguards the boiler without interfering with furnace pressure. Carryover has been eliminated, the insurance company is satisfied, and maintenance is a fraction of its former cost.

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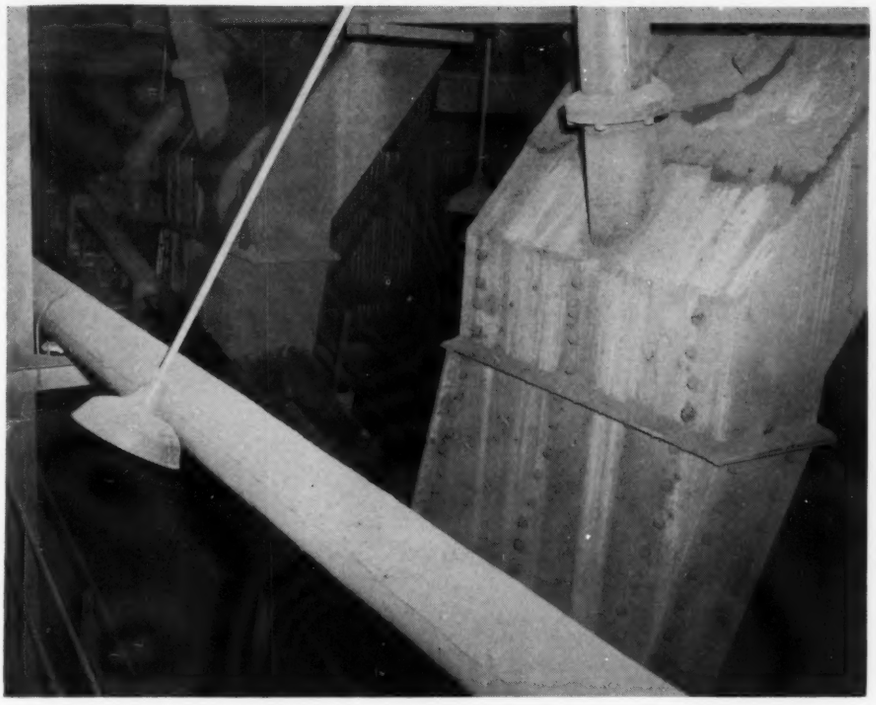
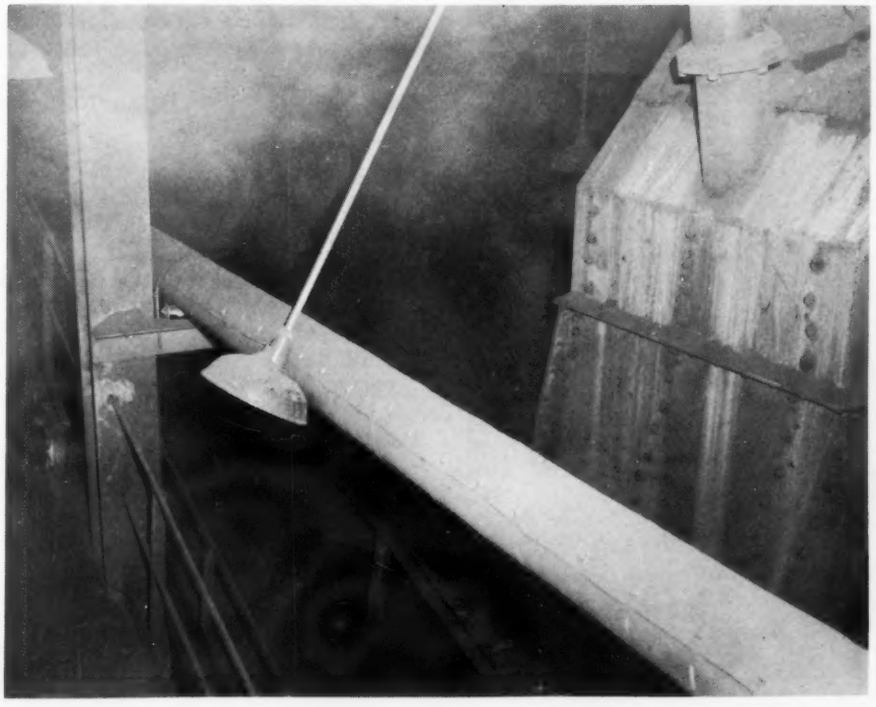


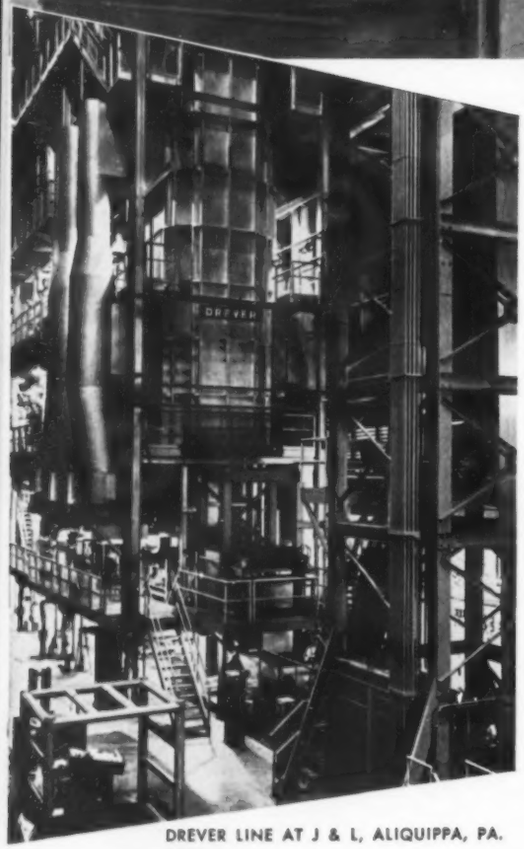
**Figure 4 — With the spray system in operation the dust level is very low.**

to the installation of the system, draw off ducts and fans were installed in the screen. This draw off was fed to a multiple-cyclone dust collector that removed substantial amounts of dust. Even after passing through the cyclones, the effluent of the stack was a continuous stream of dark, red dust. Now, the draw off system is disconnected as there is no dust for it to collect.

The reduced cost of cleanup time should pay for the entire system in a year to 18 months. There are additional savings resulting from the reduction of equipment maintenance costs. Although costs of this nature are indeterminate in most plants, wear on conveyor rollers and bearings is certainly influenced by the amount of abrasive dust and grit present. ▲

**Figure 5 — With the spray system turned off the dust level increases substantially.**



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"Convecool" provides greater cooling atmosphere contact with the strip in a balanced design that can only fail safe without product spoilage or equipment damage. In contrast with complex water systems or multiple motor-blower-heat exchanger arrangements, the "Convecool" unit utilizes a modicum of moving parts in a simplified design that allows immediate, complete accessibility for maintenance or quick repair. Now in operation at the Aliquippa Works of Jones & Laughlin Steel Corp., the "Convecool" section of the Drever Annealing Line can handle strip up to 2000 fpm. At 1000 fpm strip is cooled from 900°F to 150°F in 43 seconds.

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*FOR PUMPS,* J-M CHEMPAC® (white) combines the excellent sealing and heat-resistant qualities of asbestos with Teflon's immunity to almost all chemical and solvent action. Chempac Style No. 2009 is recommended to give you long, efficient and economical service on the majority of your pump, expansion joint and agitator applications.

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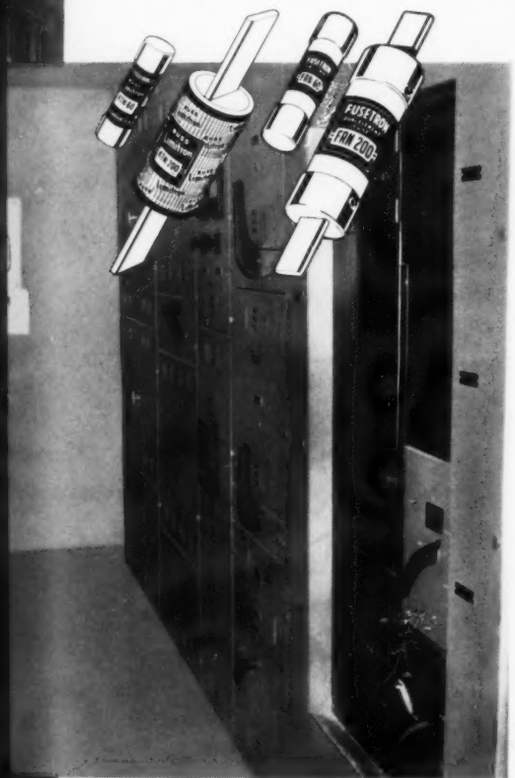
To meet power requirements, the capacity of the electrical system was greatly increased, resulting in an estimated available fault current level approaching 100,000 amperes.

In the main switchboard, Buss LIMITRON fuses are installed to provide the high interrupting capacity necessitated by the available fault current and to give great current limitation needed to protect circuits and equipment.

To further assure safe protection and to safeguard against needless outages, distribution and feeder circuits are equipped with FUSETRON dual-element fuses.




*Part of Main Switchboard Protected by:*
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As electrical network capacities increase, available fault currents of 75,000 to 100,000 amps and up are no longer uncommon.

In order to adequately safeguard circuits and equipment, it becomes imperative to install protective devices that can safely interrupt these fault currents.

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Fuses provide high interrupting capacity at a very low cost. Buss LIMITRON fuses have an interrupting rating of 200,000 amps. rms symmetrical — and for FUSETRON dual-element fuses it is 100,000 amps.

### CURRENT LIMITATION

Buss LIMITRON fuses also provide current limitation so that fault currents are shut-off before equipment on the circuit can be damaged.

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Fuses remain safe and accurate through the years. Fuses have no triggers, latches, pivots or contacts to stick or get out of order. They require no expensive maintenance or recalibration — they are always ready to function the instant trouble occurs.

*To help you select the proper fuse, write for the new BUSS booklet . . .*
**BASIC PROTECTION FOR ELECTRICAL POWER SYSTEMS.**

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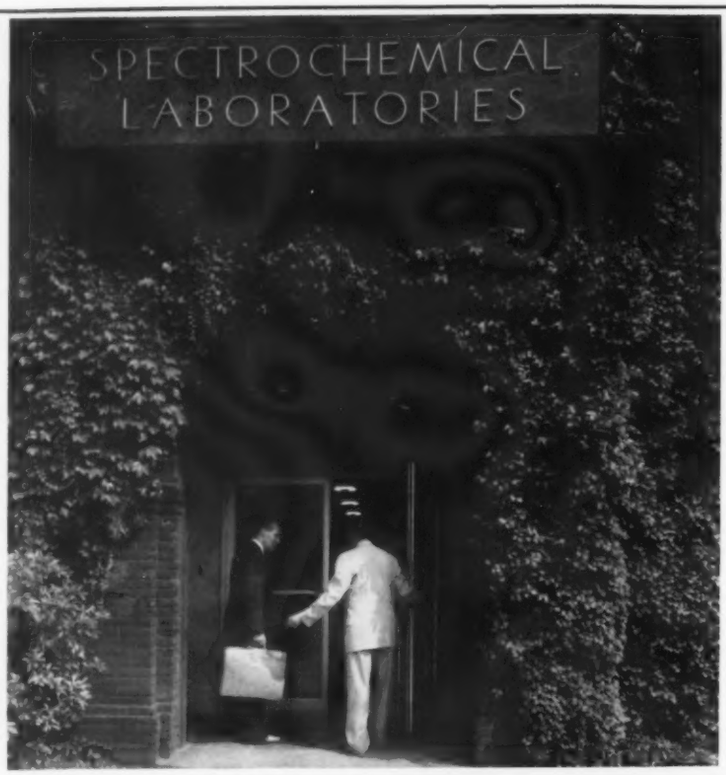


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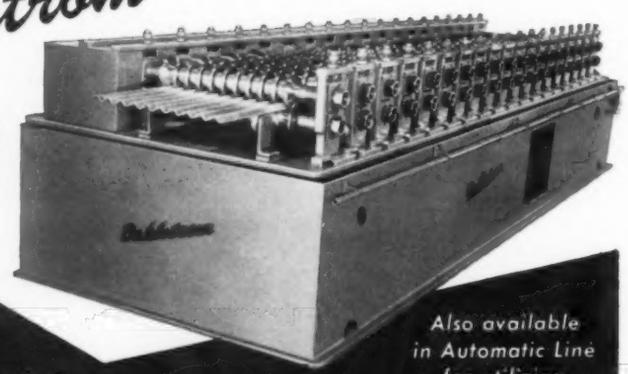

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B&W Kaocrete-D, vibrated in place, provides high resistance to the atmospheres encountered in this coke oven door installation. Furthermore, the high erosion resistance and long service life without loss of strength of B&W Kaocrete-D add to its suitability in this application.

A typical monolithic curb wall construction in an annealing furnace using a carbon monoxide atmosphere. The greatly reduced number of joints in which sealing sand can penetrate prevents structural spalling of B&W Kaocrete-A upon heating and cooling. Being monolithic, gas leaks are practically eliminated.

A radiant tube annealing furnace with a base of Kaocrete-A, backed up with Kaolite-20, one of B&W's insulating refractory castables. This furnace operates at approximately 1700 F in a 65% CO atmosphere.

A stack annealing furnace with pedestals cast of B&W Kaocrete-A. The atmosphere is slightly above 8% CO. B&W Kaocrete-A offers strength, volume stability and resistance to carbon monoxide disintegration.

## How B&W refractory castables perform in atmosphere applications

One of the difficult problems facing furnace builders and operators in the metals industries is the effect of atmospheres on refractory linings. That's why B&W offers several *specialized* refractory castables for this service, each possessing strength, volume stability and the refractoriness necessary to assure long, trouble-free service.

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*B&W Bulletin R-35A gives additional information on versatile B&W refractory castables. Write for your copy of this bulletin to The Babcock & Wilcox Company, 161 East 42nd Street, New York 17, N. Y.*

R832

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# Date-line Diary...

*March 1*

Δ The Bureau of the Census reports that shipments of nonferrous castings in December, 1960, totaled 164,417,000 lb compared with 176,682,000 lb in November, 1960.

Δ The AISC reported that shipments of fabricated structural steel in January, 1961, totaled 231,530 tons, compared with 246,196 tons in December, 1960. Bookings in January, 1961, totaled 272,177 tons compared with 222,478 tons in December, 1960. Backlog on January 31, 1961 totaled 2,098,417 tons.

Δ The Dept. of Commerce reports that shipments of iron and steel castings in November, 1960, totaled 997,264 net tons compared with 1,071,324 tons in October, 1960, and 998,461 tons in November, 1959.

*March 2*

Δ Can Manufacturers Institute, Inc., reports that canmakers consumed 345,782 tons of steel in December, 1960, an increase of 9.1 per cent compared with December, 1959. Aluminum cans totaled 1800 tons.

Δ The House of Representatives approved the use of $990,000,000 in Federal funds to provide unemployment payments for jobless workers who have exhausted their state benefits.

Δ The Dept. of Commerce reported that world steel production in 1960 totaled 355,600,000 net tons compared with 321,000,000 tons in 1959.

Δ The Dept. of Commerce reported that 1960 steel exports totaled 3,000,000 net tons worth $600,800,000 compared with 1960 imports of 3,400,000 tons worth $448,800,000.

*March 4*

Δ The AISI reported that steel production for the week ending March 4, 1961, totaled 1,580,000 net tons (55.4 per cent of capacity) compared with 1,582,000 tons one week ago (55.5 per cent of capacity) and 2,645,000 tons one year ago. Index of production for the week was 84.8.

*March 6*

Δ The National Machine Tool Builders Assn. reports that new orders of metal cutting and forming type machine tools totaled $55,150,000 in January, 1961, compared with $59,250,000 in December, 1960. Shipments in January, 1961, totaled $45,850,000 compared with $60,450,000 in December, 1960.

Δ American Iron Ore Assn. and AISI joint reports show receipts of iron ore in the United States for January, 1961, amounted to 2,601,619 gross tons, compared with 4,643,865 in January, 1960. Consumption in 1961 to January 31, amounted to 6,217,812 gross tons, compared with 11,855,949 tons in January, 1960. Blast furnaces in operation on January 31, 1961, totaled 112 of 256. On January 31, 1960, 226 blast furnaces were in operation.

Δ A Federal survey reports that expenditures for new plants and equipment for 1961 will be $34,600,000,000. a decrease of three per cent compared with 1960.

*March 7*

Δ The Bureau of Mines reported that consumption of scrap in November, 1960, totaled 4,412,766 net tons, compared with 4,373,000 tons in October, 1960; pig iron consumed in November, 1960, totaled 4,115,700 net tons, compared with 4,019,000 tons in October, 1960.

Δ International Nickel Co.; Inc., reported 1960 net earnings of $80,701,000, equal to $2.76 per share (adjusted to reflect two for one stock split), compared with 1959 net earnings of $85,157,000 equal to $2.91 per share.

*March 8*

Δ The Dept. of Commerce reports that shipments of iron and steel castings in December, 1960, totaled 914,224 tons, compared with 997,264 tons in November, 1960, and 1,320,938 tons in December, 1959.

Δ The Bureau of Mines reported Pennsylvania anthracite production for February, 1961, was 1,725,000 net tons compared with 1,803,000 tons in January, 1961, and 1,579,000 tons in February, 1960.

Δ Labor Secretary Goldberg reported that unemployment in the month ending February 15, 1961, rose 320,000 to a total of 5,705,000, a 20-year high.

Δ The AISI reports that the steel industry's employment of hourly and salaried workers in January, 1961, totaled 477,543, compared with 485,906 in December, 1960, and 640,933 in January, 1960. The payroll for hourly and salaried workers combined for January, 1961, totaled $274,484,989, compared with $267,882,401 during December, 1960, and $398,789,456 in January, 1960. Hourly rate in January was $3.431, compared with $3.370 in December, 1960, excluding estimated employe fringe benefits costing 47.1¢ per hour, and $3.399 in January, 1960. Wage earners worked 34.3 hours a week during January, against 32.8 hours per week in December, 1960.

*March 10*

Δ Interlake Iron Corp. reported 1960 revenues of $91,082,796, net earnings of $4,157,996, equal to $1.85 per share, compared with 1959 sales of $115,418,531, net earnings of $7,301,726, equal to $3.25 per share.

*March 11*

Δ The AISI reported that steel production for the week ending March 11, 1961, totaled 1,573,000 net tons (55.1 per cent of capacity) compared with 1,580,000 tons one week ago (55.4 per cent of capacity) and 2,654,000 tons one year ago. Index of production for the week was 84.4.

*March 13*

Δ The AISI reported that shipments of finished steel products in January, 1961, totaled 4,637,970 net tons, compared with 4,100,000 tons in December, 1960.

Δ The Bureau of the Census reported that commercial exports in January, 1961, totaled $1,400,000,000, a decrease of 16 per cent compared with December, 1960.

Δ Laclede Steel Co. reported 1960 sales of $70,248,910, net earnings of $3,906,089, equal to $18.94 per share, compared with 1959 sales of $87,671,707, net earnings of $5,632,652, equal to $27.31 per share.

*March 14*

Δ United States Pipe and Foundry Co. reported 1960 sales of $103,016,480, net earnings of $6,594,915,

equal to $1.78 per share, compared with 1959 sales of $119,865,906, net earnings of $10,863,856, equal to $2.94 per share.

Δ Phoenix-Rheinrohr A.G. reported 1959–60 fiscal year (October 1, 1959 to September 30, 1960) sales of $445,750,000, net earnings of $7,245,000, equal to $3.02 per share, compared with 1958–59 sales of $347,750,000 and net earnings of $5,175,000.

Δ The AISI reported that steel production for February, 1961, totaled 6,233,000 net tons, compared with 6,416,004 tons in January, 1961. Index of production for February, 1961 was 83.6, compared with 77.8 for January, 1961.

Δ The Bureau of the Census reports that imports in January, 1961, totaled $1,100,000,000, a decline of three per cent compared with December, 1960. The excess of exports over imports in January, 1961, was $347,000,000, compared with $464,000,000 excess in December, 1960.

*March 15*

Δ The Bureau of Mines reported that consumption of scrap in January, 1961, totaled 4,056,000 gross tons, compared with 3,738,385 tons in December, 1960; pig iron consumption in January, 1961, totaled 3,682,000 gross tons, compared with 3,426,941 tons in December, 1960.

*March 17*

Δ The Bureau of the Census reported that shipments of steel forgings in January, 1961, totaled 100,347 net tons compared with 89,601 tons in December, 1960. Unfilled orders at the end of January, 1961, totaled 289,234 net tons compared with 268,217 tons at the end of December, 1960.

Δ United States Steel Corp.'s National Tube Div. reported a one per cent increase in its mill price for all grades of 4½, 5 and 5½-in. O.D. oil well casing.

*March 18*

Δ The AISI reported that steel production for the week ending March 18, 1961, totaled 1,574,000 net tons (55.2 per cent of capacity), compared with 1,573,000 tons one week ago (55.1 per cent of capacity), and 2,607,000 tons one year ago. Index of production for the week was 84.5.

*March 20*

Δ The Aluminum Assn. reported that primary aluminum production in February, 1961, totaled 138,560 net tons, compared with 161,427 tons in January, 1961, and 156,826 tons in February, 1960.

Δ The Aluminum Assn. reports shipments of aluminum sheet and plate in January, 1961, totaled 113,890,000 lb, compared with 101,016,000 lb in December, 1960; shipments of aluminum foil in January, 1961, totaled 19,206,326 lb compared with 19,841,475 lb in December, 1960.

Δ The ARCI reported that deliveries of new freight cars in February, 1961, totaled 1958 compared with 3515 in January, 1961, and 5052 cars in February, 1960. Orders in February, 1961, totaled 1536, compared with 1339 in January, 1961, and 3211 in February, 1960. Backlog of cars on order as of March 1, 1961, totaled 18,429 compared with 18,894 on February 1, 1961, and 46,323 on March 1, 1960.

Δ United States Steel Corp. and its Tennessee Coal and Iron Div. cut mill prices of black and tin plate by 10¢ per base box at the Fairless, Pa., and Fairfield, Ala., plants.

*March 23*

Δ United States Steel Corp. reported that partial operation of its Ironton, Utah, plant, closed since last fall, has been scheduled for the first week in April.

*March 24*

Δ F. W. Dodge Corp. reported that total construction contracts in the U. S. for February, 1961, amounted to $2,235,367,000, compared to $2,239,534,000 in February, 1960.

Δ The Bureau of the Census reported that net shipments of aluminum pig and ingot in January, 1961, totaled 101,357,000 lb compared with 152,141,000 lb in December, 1960. Net shipments of aluminum mill products in January, 1961, totaled 242,162,000 lb compared with 226,895,000 lb in December, 1960. Net shipments of magnesium mill products in January, 1961, totaled 1,658,000 lb compared with 1,195,000 lb in December, 1960.

*March 25*

Δ The AISC reported that steel production for the week ending March 25, 1961, totaled 1,611,000 net tons (56.6 per cent of capacity), compared with 1,574,000 tons one week ago (55.2 per cent of capacity), and 2,597,000 tons one year ago. Index of production for the week was 86.5.

*March 27*

Δ The National Machine Tool Builders Assn. reports that net new orders of cutting and forming type machine tools in February, 1961, amounted to $46,000,000 compared with $56,100,000 in January, 1961. Shipments of cutting and forming type machine tools in February, 1961, amounted to $45,950,000 compared with $45,500,000 during January, 1961.

Δ The AISC reported that fabricated steel shipments during February, 1961, totaled 230,228 tons compared with 231,530 tons in January, 1961, and 240,850 tons in February, 1960. Bookings in February, 1961, totaled 227,317 tons compared with 272,177 in January, 1961, and 288,825 in February, 1960. Backlog on February 28, 1961, totaled 2,086,156 tons.

Δ The Japan Iron and Steel Federation reports that production of ingot steel in Japan in January, 1961, totaled 2,203,300 net tons; pig iron 1,300,200 net tons.

Δ The Labor Dept. reported that consumer prices rose 0.1 per cent in February, 1961, to 127.5 per cent of the 1947–49 average.

*March 29*

Δ United States Steel Corp. reports that it will offer $300,000,000 of 25-year sinking fund debentures to raise additional working capital.

Δ The Bureau of the Census reported that net shipments of aluminum pig and ingot in 1960 totaled 1,609,672,000 lb compared with 1,575,003,000 lb in 1959. Net shipments of aluminum mill products in 1960 totaled 3,048,077,000 lb compared with 3,386,052,000 lb in 1959. Net shipments of magnesium mill products totaled 20,656,000 lb in 1960 compared with 22,169,000 in 1959.

Δ The Bureau of the Census reported that shipments of nonferrous castings in January, 1961, totaled 167,096,000 lb compared with 165,998,000 lb in December, 1960.

*March 30*

Δ The Bureau of the Census reported that titanium ingot production in January, 1961, totaled 1,627,832 lb, compared with 1,828,035 lb in December, 1960. Shipments of titanium mill products in January, 1961, totaled 1,066,541 lb, compared with 1,186,309 lb in December, 1960.

Δ The Bureau of the Census reported that estimated new construction expenditures in March, 1961, will total $3,900,000,000.

Another MX Test System at work...

*Magnatest eddy current unit, in which magnetic continuous weld pipe is tested for serious defects as it passes through sensing coils. Fully mechanized handling and automatic marking also provided by Magnaflux Corporation.*

# New Selective Eddy Current Test for Continuous Weld Pipe

This particular Magnatest SD-100 is one of a series of new Magnaflux-developed inspection systems for testing continuous butt-weld pipe and electric weld tubing. It precisely locates and marks the defects you want to find—at speeds to 600 feet per minute or more, on diameters up to 4".

The SD-100 is selective. It can be used to find varying degrees of gross defects. It will locate ring welds, caves, dents, scabs, saw cuts, slivers, burned welds, cold worked areas. Your needs are the determining factor . . . and with automatic marking and mechanized handling, available from Magnaflux, the per shift testing rates are determined mainly by your particular requirements.

Whether you test continuous butt-weld pipe or almost any other magnetic pipe, rod or wire, find out how one of the many MX Test Systems can help you standardize quality and cut costs—per foot, per day or per 100 miles! Phone our local Magnaflux Field Engineer, or write Magnaflux Corporation, 7332 W. Lawrence Avenue, Chicago 31, Illinois.

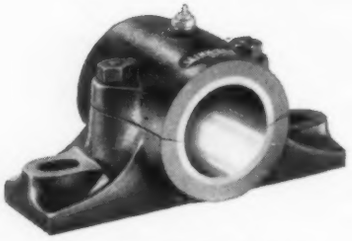
MAGNAFLUX CORPORATION
A SUBSIDIARY OF GENERAL MILLS
General Mills
TEST SYSTEMS

MX Test Systems include MAGNETIC PARTICLE, FLUORESCENT PENETRANT, THERMOGRAPHIC, EDDY CURRENT, ULTRASONIC, STRESS ANALYSIS, RADIOGRAPHIC TESTING, DYE PENETRANT & MAGNETIC FIELD

# Choose Link-Belt as your one-source headquarters for

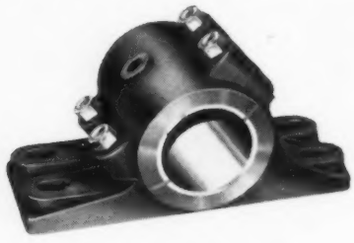
**SOLID PILLOW BLOCKS**

Gray iron housings, babbitted or bronze bearings—or plain bored bearings; for ½ to 2 15/16" shafts.



**SPLIT PILLOW BLOCKS**

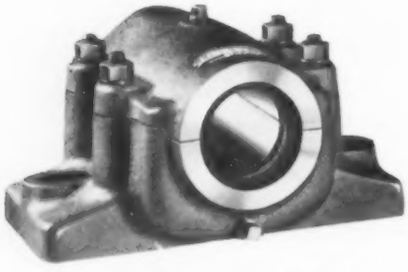
Split and split-gibbed types; gray iron or cast steel housings; bronze or babbitted; 2-bolt for ½ to 3" shafts; 4-bolt for 1 15/16 to 12" shafts.



**ANGLE PILLOW BLOCKS**

For heavy angular loads; split gray iron housings; babbitted or bronze bearings; 2-bolt for 1 7/16 to 2 15/16" shafts; 4-bolt for 1 15/16 to 9" shafts.

# babbitted and bronze bearings

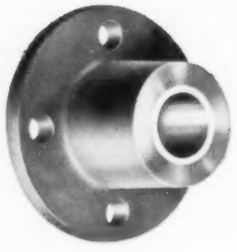


**RING-OILING PILLOW BLOCKS**

Split housings; babbitted bearings; self-lubricated; 2-bolt for 1 3/16 to 2 15/16" shafts; 4-bolt for 1 11/16" to 3 15/16" shafts.

**FLEX-BLOCK SLEEVE BEARINGS**

Self-aligning, self-lubricating, with sleeves to suit various operating conditions; pillow and flanged block types; for shafts from 5/8 to 3 15/16".



**FLANGED BLOCKS**

Solid gray iron housings; babbitted bearings; 4-, 6- or 8-bolt flanges with machine-finished faces; for 15/16 to 5 7/16" shafts.

## Over 15 types, more than 350 sizes . . . and all these features besides!

- **DURABLE, COMPACT HOUSINGS** of cast gray iron or cast steel provide exceptional strength where needed, without excess size or weight.
- **PRECISION-MACHINED BORES** provide correct running clearance between shaft and bearing metal for load carrying oil or grease film.
- **STURDY BEARINGS** of heavy-duty babbitt or high-quality bronze are anchored in housing.
- **ACCURATELY MACHINED BASES** assure firm seating on supports.
- **FINISHED ENDS** permit flush mounting of sprockets, pulleys, wheels and collars against bearings.
- **SHIMS** between cap and base of split housings provide shaft clearance adjustment, compensate for wear.
- **SLOTTED BOLT HOLES** in bases allow easy adjustment for shaft alignment.
- **RELIABLE LUBRICATION**—Holes for grease cups or pressure fittings are drilled and tapped. Grooves distribute lubricant over entire shaft surface. (Flex-Block and ring-oiling types are self-lubricating.)
- **OFF-THE-SHELF DELIVERY** is offered by Link-Belt on over 15 types and more than 350 sizes of babbitted and bronze bearing pillow and flanged blocks . . . for commercial shafting up to 12" diameter. Also immediate delivery on takeups in all popular sizes.

For complete information, contact your nearest Link-Belt office or authorized stock-carrying distributor. Look under BEARINGS in the yellow pages of your telephone book. Ask for Book 2707 and Folder 2823.

**LINK-BELT**

**BABBITTED AND BRONZE BEARINGS**

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World. 15,641

Now... More Than

# 7 MILLION TONS AHEAD

PEC DR

## Basic Oxygen Converters

As the world's only maker of oxygen converters larger than 100 tons . . . Pennsylvania Engineering has furnished vessels and auxiliaries with which America's entire output of oxygen-converted steel has been produced — more than 7 million tons. • The record demonstrates: RELIABILITY — equipment notable for staying on-the-line and making steel. QUALITY in design and manufacture, reflecting unique experience and precision engineering. SERVICE — immediate response to field requirements.

May we consult with you in the planning stage of any project involving oxygen converters, ladles, hot metal mixers, cars and related equipment for processing molten iron or steel?

Pennsylvania Engineering

CORPORATION NEW CASTLE, PA.

Sales Representatives: Wooldridge Company, Burlingame, Calif.
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Licensees: Ashmore, Benson, Pease & Company, Ltd., England
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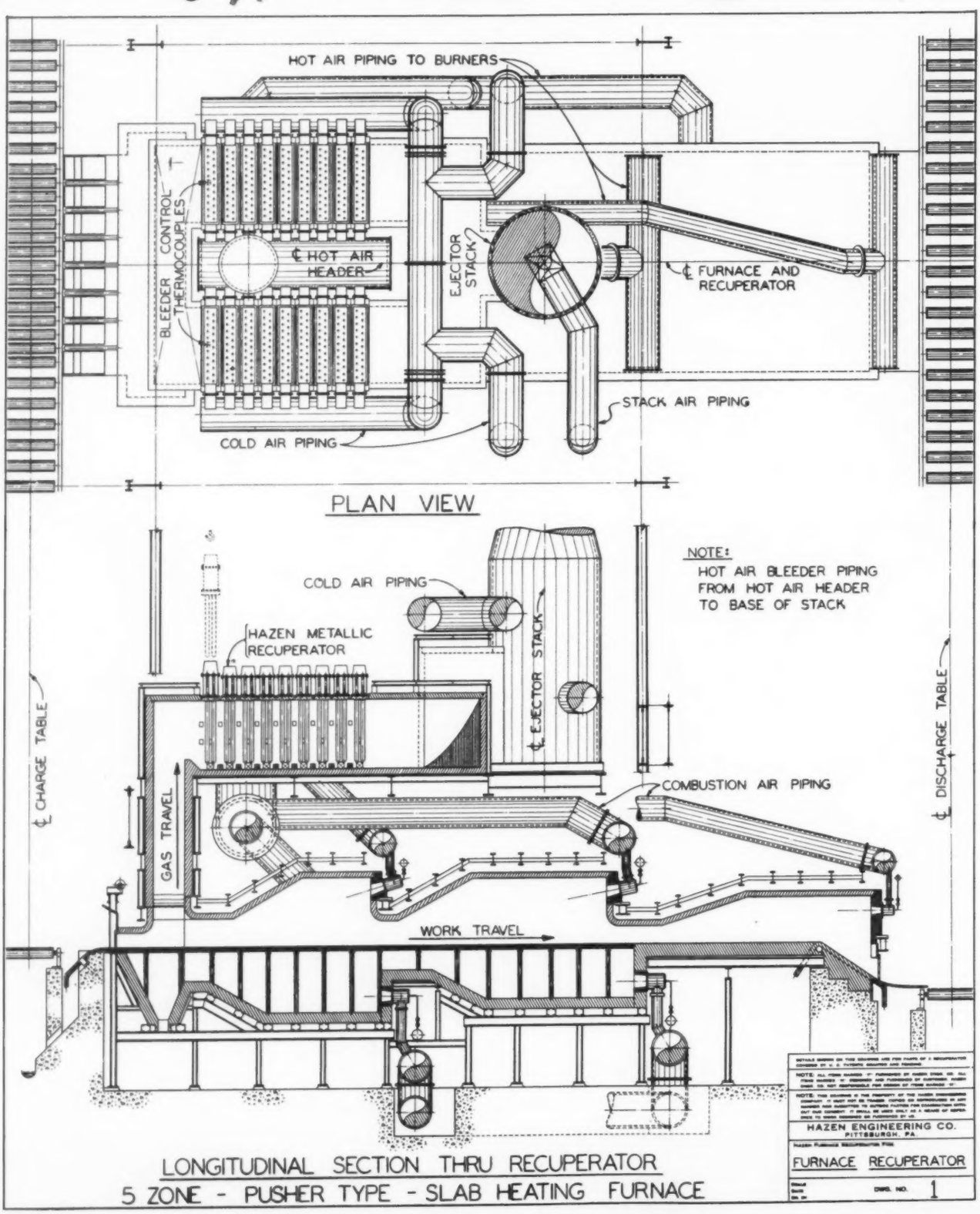
BUILDER OF AMERICA'S FIRST 15 OXYGEN CONVERTERS

# HAZEN *Metallic*

*service-proven*

## The only Metallic Recuperators




LONGITUDINAL SECTION THRU RECUPERATOR
5 ZONE - PUSHER TYPE - SLAB HEATING FURNACE

© 1961

# RECUPERATORS

## for 5-Zone Furnaces

*The drawing at left shows application of Hazen metallic recuperator to 5-zone slab or billet reheating furnaces . . . now boosting mill capacity of leading steel producers.*

- ☆ Performance of Hazen metallic recuperators on new and existing furnaces is unapproached by any other recuperator.
- ☆ Increased mill capacity through furnace acceleration has meant millions of dollars for the steel industry.
- ☆ Preheated air is provided *with pressure* to burners . . . Maximum furnace production . . . Minimum fuel consumption.
- ☆ Hazen is responsible for the trend from refractory to metallic recuperators . . . to increase tonnage and improve quality.
- ☆ Hazen patented welding process assures weld life equal to parent material, resulting in greater longevity.

WARNING!

**Do not confuse Hazen METALLIC recuperators with inferior types that have failed to perform as claimed. Such failures have caused a few expressions of doubt about metallic recuperator durability.**

**Actually there is NO DOUBT about the superiority of the PATENTED Hazen metallic recuperators.**

# Hazen Engineering Company

184 Sandy Creek Road (Penn Hills)
P.O. Box 10597, Pittsburgh 35, Pa.

*Ask for Brochure containing Facts by Metallurgical Heating Authorities*

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15

America's Only Designer Manufacturer of M & M

# Bill Overturf Runs an Ingot Buggy from the Turnaround Pulpit

Bill is a table operator at the Fontana plant of Kaiser Steel Corporation.

Among other duties, he runs the ingot buggy on its return trip to the soaking pits. With a FEMCO system of remote and automatic control, running the buggy presents no problem. Bill merely flips a switch to select the pit and presses a button to start the buggy. The buggy stops automatically at the selected pit and stays there until the cover carriage operator sends it back to the pulpit. At the laydown table it again stops automatically and positions itself for dumping. An interlock prevents operation of the dumping mechanism unless the buggy is in the correct position.

Special features of this installation include a graphic panel which gives a continuous indication of buggy travel; complete duplicate panel and controls on the operating platform; emergency stop control from any cover carriage station; and an anti-collision system which permits simultaneous operation of a second buggy on the same track.

FEMCO systems for the metals industry are engineered to meet your requirements. We have designed and built many systems, for many plants, in all parts of the country. We will be glad to tell you about them, and to discuss any problem of remote and automatic control with which you may be concerned.

**Femco** INCORPORATED

**COMMUNICATIONS:** Carrier and wired audio systems for all mining and industrial applications. **MONITORING:** Fans, circuit breakers, valves, pumps, compressors, etc. **TELEMETERING:** Flows, pressures and other functions. **REMOTE CONTROL:** Pumps,

Lou Krakowski, General Superintendent of the Harrison Sheet Steel Company, is a guy who makes no bones about what he wants. It's service! And, for twenty years, he has been getting what he considers the best . . . Cities Service.

Turning out, among many other things, 125 steel desks a day, he wants complete and dependable lubrication service. One of the many Cities Service products he uses to get this job done is Trojan H-2 grease. For general greasing on all equipment, multi-purpose Trojan H grease has a wide range of application. And, because of the variety of jobs Trojan H grease does, it reduces his necessary lubrication stocks.

If you have to *get it on the line* . . . call your nearest Cities Service office . . . or write Cities Service Oil Company, 60 Wall Street, New York 5, N. Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

# Ohio Rolls

## Shaping Metal for all Industry

**THE OHIO STEEL FOUNDRY COMPANY**
**LIMA, OHIO**

## OHIO IRON and STEEL ROLLS

| | | |
|---|---|---|
| Carbon Steel Rolls | Flintuff Rolls | Denso Iron Rolls |
| Ohioloy Rolls | Double-Pour Rolls | Nickel Grain Rolls |
| Ohioloy "K" Rolls | Chilled Iron Rolls | Special Iron Rolls |
| Nioloy Rolls | Forged Steel Rolls | |

PLANTS AT LIMA AND SPRINGFIELD, OHIO. . *Virtually at the center of the Steel Industry*

OR-47

# Industry News...

## INLAND NOW PRODUCING THIN GAGE TIN PLATE

△ Production of thin gage tin plate has begun at Inland Steel Co.'s Indiana Harbor Works. The material, known as thin tin, is no thicker than two newspaper pages, and is made by producing tin plate in the conventional manner and then reducing it to half its original thickness by an extra cold rolling.

Robert M. Buddington, sales vice president, said that the greatest interest in thin tin appears currently to be for manufacture of beer and motor oil cans.

"We think this light tin plate will become a major item," he said. "We will be set up to produce substantial tonnage and plan to increase our output to the extent that our can manufacturing customers convert their equipment to use it."

The thin tin is described as 45 to 60 lb per base box which compares with 60 to 120 lb and more for conventional tin plate. A base box is the trade's traditional unit of measurement for tin plate and amounts to approximately 218 sq ft of metal.

Inland will produce thin tin on existing equipment using the newest of its three electrolytic tinning lines. It was completed last September in an expansion move that lifted the company's tin plate capacity 65 per cent to 435,000 tons a year.

## CAN FIRM INSTALLING NEW COIL CUTTING LINES

△ National Can Corp. has announced the purchase of four coil cutting lines, to be used for the shearing of metal for the manufacture of metal containers.

Current plans call for the immediate installation of one of the lines in National Can's Pacific Division, and one in the Central Division, according to S. M. Hopkins, president.

The coil cutting lines, a departure from past manufacturing methods, permit National Can to use large coils of plate in place of precut sheets now being furnished by steel mills. The equipment is designed to inspect, shear and sort plate at high speeds at close tolerances.

The new process permits a reduction in the amount of waste stock, plus a more flexible and economical operation.

National Can several years ago prepared for a coil cutting operation but postponed the program until a substantial costs savings could be assured. The present adoption of this program follows improvements in equipment, a better determination of its most effective uses, and developments that insure effective operation without costly experimentation.

Operating by remote control, the line uncoils, straightens, feeds and shears tin plate as thin as 0.007 in., and steel stock as thick as 0.02 in.

## NEW UNIT TO GRIND ROD MILL ROLLS

**"Crushtrue" grinding several grooves simultaneously on a small rod mill roll on a modified Sheffield Corp. No. 181 Multi-Form Grinder. A larger model machine, the Model No. 190, is now being designed and built to handle rolls up to six ft long, 14 in. diam and 3000 lb in weight. Grinding rod mill rolls permits the use of rolls of harder metal than can be turned on a lathe. With harder rolls, more tonnage can be rolled before the grooves wear oversize. The new machine will use a 30 in. diam by 10 in. wide grinding wheel, dressed to permit multiple grooves or passes to be ground in the roll simultaneously. The machine will grind the grooves on new rolls directly from the solid as well as regrinding the grooves in worn rolls.**

## ANNEALING LINE ORDERED BY GRANITE CITY STEEL

△ Granite City Steel Co. has placed an order with Drever Co. for a continuous tin-plate strip annealing furnace line. The furnace capacity rating is to be 31 tons per hour when processing 0.0082 in. x 30 in. wide strip at 1200 fpm, and the line will be capable of processing strip as thin as 0.003 and up to 42 in. wide. It will include a combustion system suitable for operation on either coke oven or natural gas as a main fuel; complete control of the first cooling

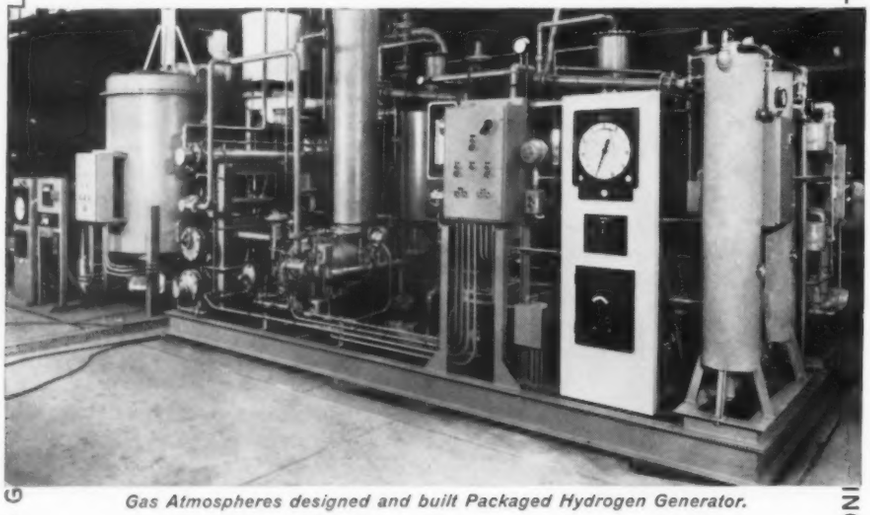
# THE FANTASTIC FUTURE OF GAS ALLOYING

The potential of modern gas alloying is virtually limitless. Metallurgists are experimenting with chromium steels, soft-core abrasive-resistant steels, and low-alloy high-strength steels. Already in production:

**BETTER ENAMELING STEELS,** resulting from almost complete carbon removal, permit white goods manufacturers to get defect-free white or colored enamel products with a single enamel coat.

**STRONGER TINPLATE,** because of pinpoint control of carbon and nitrogen content. This also enables steel makers to make many grades of tinplate from a single grade of steel.

**BETTER CARBON CONTROL** for the production of better carbon steels. More uniform carbon distribution results in better carbon steel products. Non-aging rimmed steels are now possible, as are improved silicon steels.



*Gas Atmospheres designed and built Packaged Hydrogen Generator.*

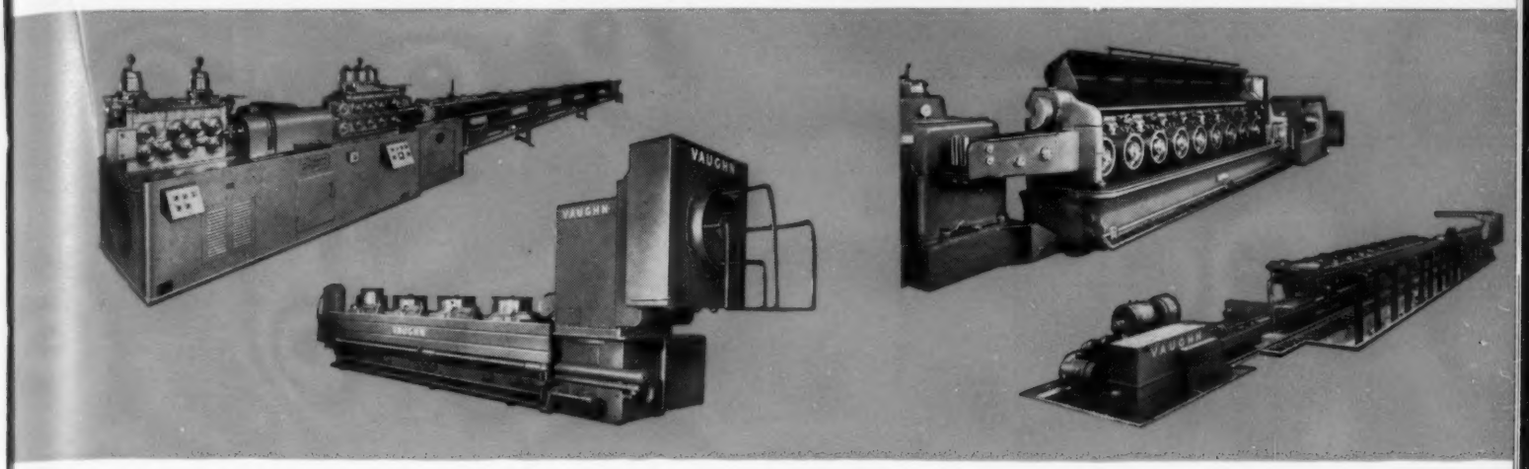
**PACKAGED GAS SYSTEMS** for the production of hi-purity nitrogen, carbon and hydrogen gases have helped make this revolutionary new process possible. A pioneer and leading producer of packaged gas systems designed for gas alloying is *Gas Atmospheres, Inc., 3855 West 150th Street, Cleveland 11, Ohio.*

gas Atmospheres, inc

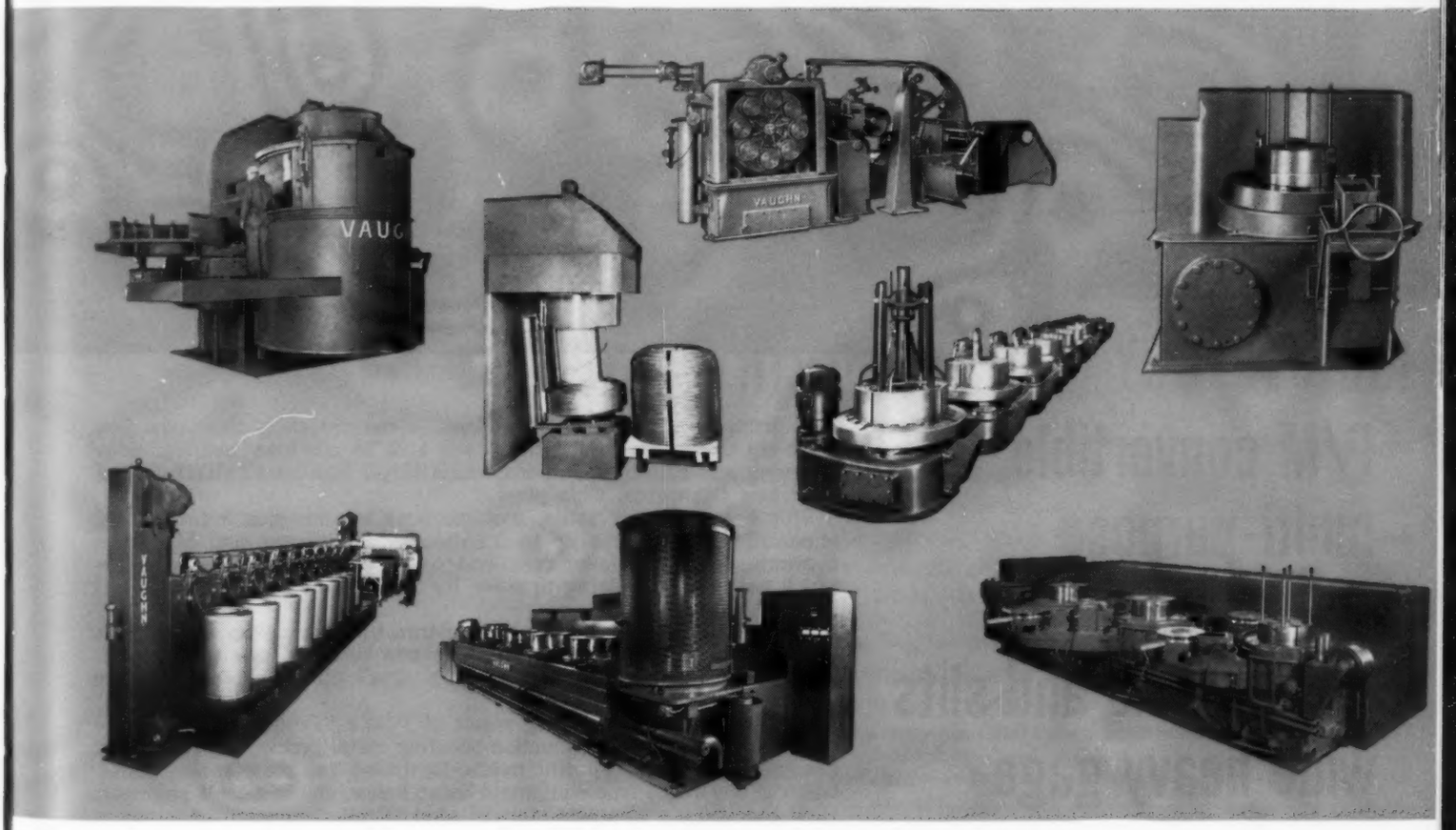
4130

GAS ALLOYING GAS ALLOYING GAS ALLOYING

# IF IT'S COLD DRAWN SEE VAUGHN!




**The World's Most COMPLETE LINE of Cold Drawing Equipment... for the largest bars and tubes... for the smallest Wire... Ferrous, Non-Ferrous Materials or their Alloys.**

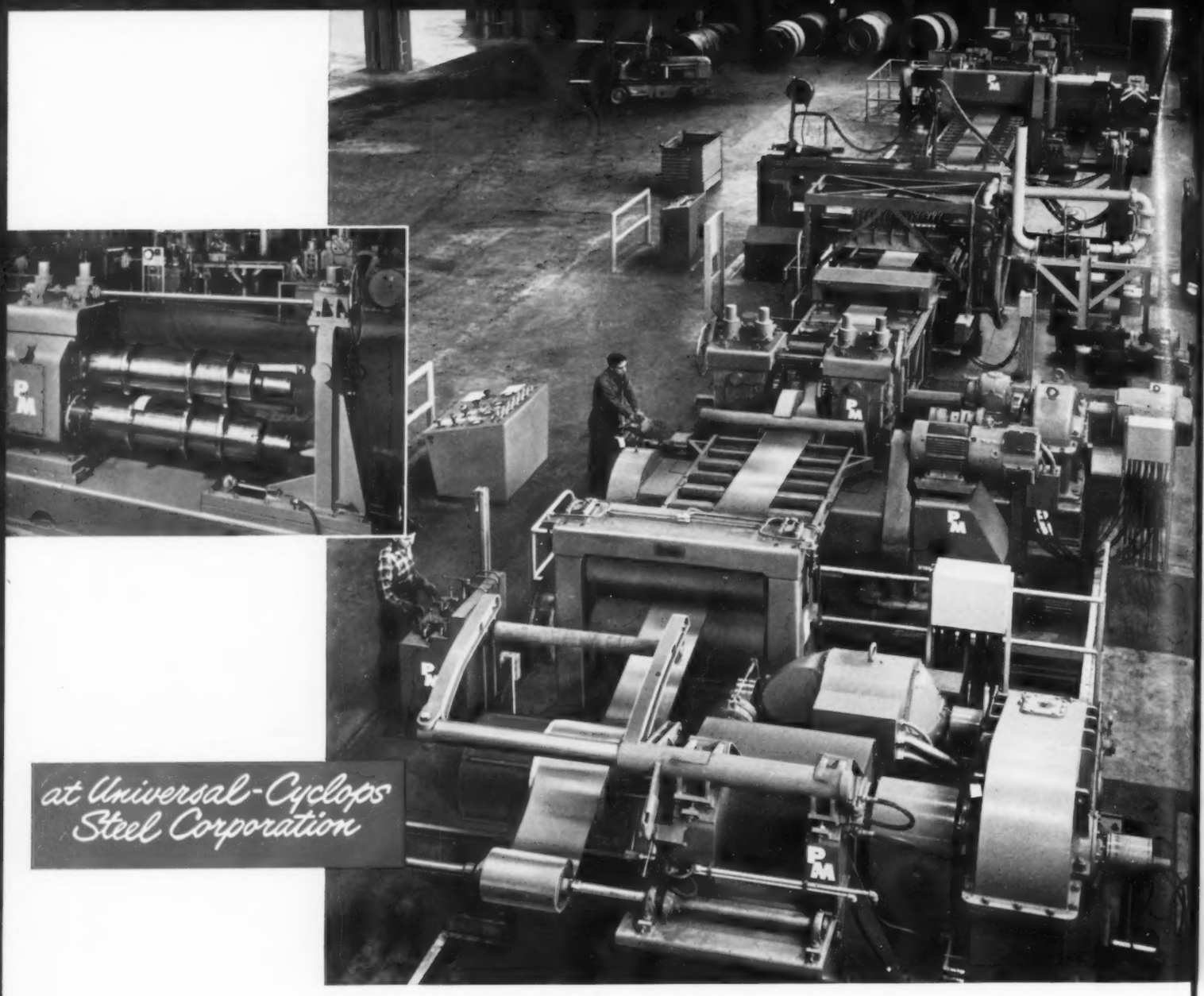



When cold drawing is part of your production picture, come to the leading equipment manufacturer for every service you may require . . . consultation, design, layout, quotations... and the broadest choice of cold drawing and related machinery in the world. You'll find Vaughn co-operation as complete as our resources. Let us serve you!

"Quick on the Draw!"

## THE VAUGHN MACHINERY COMPANY

CUYAHOGA FALLS, OHIO, U.S.A.




# P/M convertible, multi-purpose coil build-up line welds, trims and slits wide heavy gage stainless coils

By utilizing P/M's "Productioneering" in the design of their new Coil Build-Up Line, Universal-Cyclops was able to combine welding, edge trimming and slitting operations into a single high-speed installation at their new Coshocton, Ohio plant.

This heavy-duty, versatile, multi-purpose line handles hot-rolled unannealed stainless coils up to 0.250-inch in thickness and 50 inches in width. It welds smaller coils end-to-end to produce larger coils — which help cut processing time — for subsequent annealing, cleaning and pickling operations.

Normally the line is set up to side trim the moving stainless bands — but by moving the trimmer unit to one side and placing an interchangeable arbor assembly (shown in small photo) in the line, the facility doubles as a slitting line.

Here's another cost-cutting result of P/M's "Productioneering" — the exacting design of production-boosting metal processing equipment designed to fit users' specific needs. Next time you are planning installation of any of the type equipment listed below, call in a P/M engineer. He'll give you the complete story of what "Productioneered" equipment can do to improve your operations — build increased profits.

**Production Machinery Corporation, Mentor, Ohio**

P/M

Designers and Builders of Metal Processing Lines and Equipment including: lines for pickling, annealing, slitting, shearing and cutting-to-length, grinding, scouring, coil build-up, inspection, and other sheet and strip processing lines and machinery.

hot strip steel mill to be installed outside the U. S. The order has been placed by Tokai Iron and Steel Co. for its new 68-in. continuous hot strip finishing mill in Nagoya, Japan.

The system controls thickness of sheet steel produced in the mill. Included in the system will be a unique electrohydraulic-operated vernier screw control for fast response in compensating for thickness deviation.

A mill delivery x-ray gage monitors a range of strip gages between 0.039 and 0.365 in. A separate photoelectric type gage monitors widths up to 62 in. The six-stand mill will be rated to deliver hot strip at a rate of 3000 fpm.

First shipment of the equipment is scheduled for May, 1961. Prime contractor for the mill is United Engineering and Foundry Co. The mill, located about 200 miles south of Tokyo, is scheduled for completion late in 1961.

## WILL CONDUCT COURSE IN SOLID STATE MECHANICS

△ A course in solid state mechanics will be conducted by The Pennsylvania State University, Department of Engineering and Mechanics, University Park, Pa., from June 11 to 23. Lectures will be given by Dr. Joseph Marin.

The course is planned for research, design and materials engineers. Fee for the course is $175.

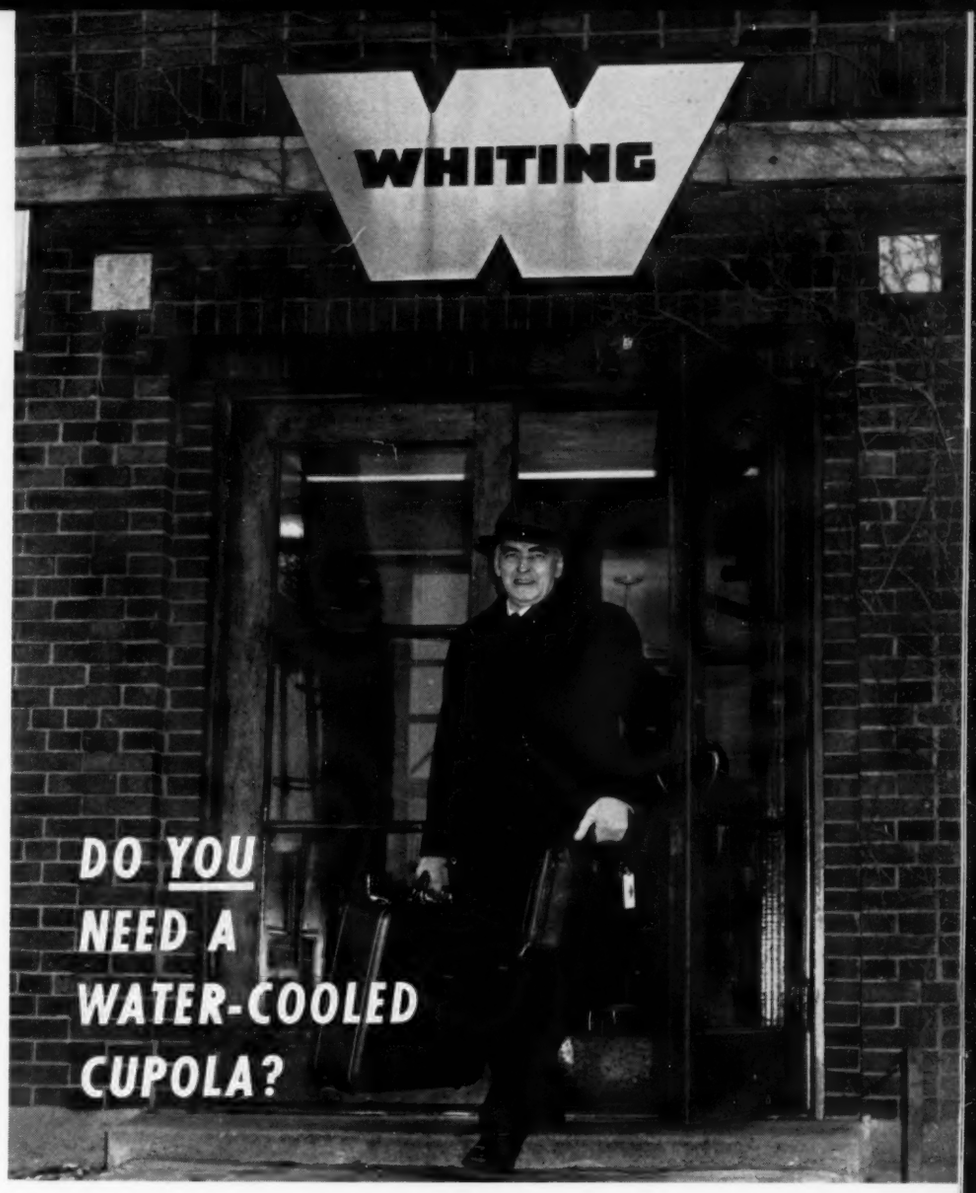
## RINGSDORFF TO FURNISH GARY CONDUCTOR SYSTEM

△ United States Steel Corp. has awarded a contract for the current conductor system at its Gary, Ind., plate mill to Ringsdorff Carbon Corp.

Ringsdorff will furnish over 24,000 ft of copper-head tee steel rail, capable of carrying 1300 amp for the crane collector rail system.

The Ringsdorff system uses steel as support and structural parts of the conductor rail, and utilizes spring-loaded collectors in its conductor systems which provide positive contact at all times.

The copper-head tee steel rails on the installation at Gary will be on 6-inch centers between rails and will withstand 40,000 RMS, amp of short circuit current.


# LET THIS MAN HELP YOU DECIDE!

**Walter R. Jaeschke** (Jas'ke) is a Whiting consulting metallurgical engineer and an international consultant on foundry cupola problems. His recommendations have slashed melting costs in Europe, South America, South Africa and Japan, as well as for scores of U.S. firms. An authority on water-cooled cupolas, he consulted extensively on the world's largest—built by Whiting for Acme Steel.

**If you are seriously debating** the merits of liningless, water-cooled cupolas, why not draw on the wealth of this man's experience? He knows intimately the conditions required to make water-cooled cupolas profitable. He also recognizes those circumstances which make them impractical or uneconomical.

**Walter Jaeschke is available**—without charge or obligation—to survey *your* needs at your convenience. Whatever his recommendations, they will be based on the dollars-and-cents requirements of your particular operation.

**FREE:** Bulletin FY-176, *Water-Cooled Cupolas.* Write Whiting Corporation, 15655 Lathrop Avenue, Harvey, Illinois. In Canada: Whiting Corporation (Canada) Ltd., 350 Alexander Street, Welland, Ontario, Canada.

90 OF AMERICA'S "FIRST HUNDRED" CORPORATIONS ARE WHITING CUSTOMERS

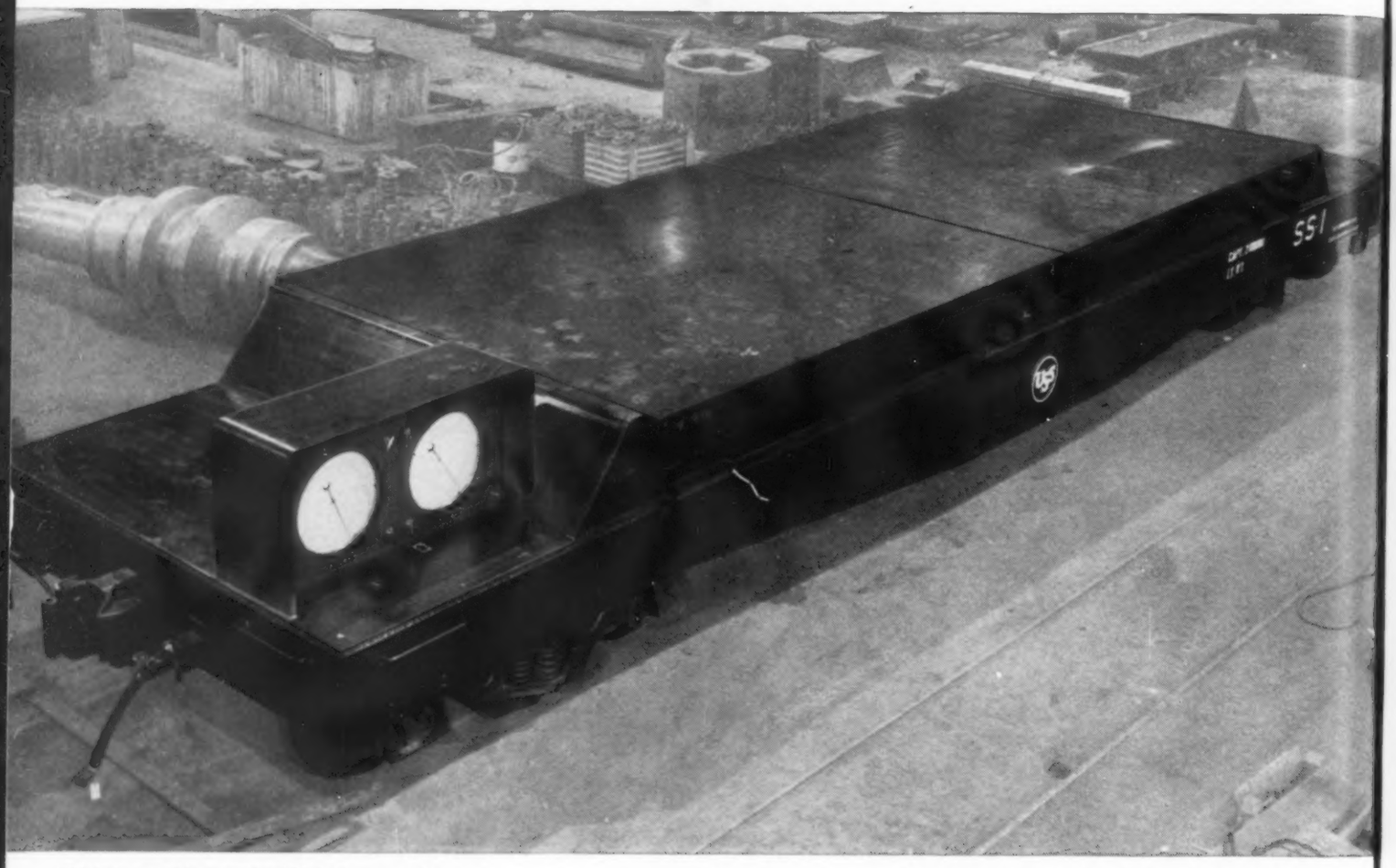
**WHITING**

MANUFACTURERS OF CRANES; TRAMBEAM® HANDLING SYSTEMS; PRESSUREGRIP; TRACKMOBILES;® FOUNDRY, RAILROAD, AND SWENSON CHEMICAL EQUIPMENT

FOUNDRY EQUIPMENT

# We think this all-purpose weigh car is too good to keep to ourselves

This mark tells you a product is made of modern, dependable Steel.




Weigh anything up to 100 tons, anywhere on the track, with this new, all-purpose weigh car. It's accurate to within two-tenths of one percent of anything up to 100 tons or two separate 50-ton loads. Because the hydraulic load cells need no power, you can weigh anywhere. A weigh car can pay for itself by eliminating guesswork and human error.

At McLouth Steel Corporation in Detroit, Michigan, they cut handling time by weighing stainless steel scrap and other expensive alloying ingredients right in their stock yard. Accurate weight records give them better control of inventory and charging mixtures and make it easier to find the yield cost. Other steel producers cut costs by weighing to control electric furnace yields. We build this all-welded, stress-relieved steel car to stand up under all of these uses and give long, dependable service.

Loading scrap at McLouth Steel does double duty because the weighing is done at the same time. This cuts handling time in the mill and gives better control of the charging mixtures.

USS Weigh Cars and other industrial cars are built to last by United States Steel, a company that also uses them! We can custom design and build any type weigh car to suit your needs. Send your weight problems to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

United States Steel Corporation, Pittsburgh
Columbia-Geneva Steel, San Francisco
Tennessee Coal & Iron, Fairfield, Alabama
United States Steel Export Company

**United States Steel**

USS

TRADEMARK

Installation of the system has already started and is expected to be completed next month.

## OXYGEN PLANT CONTRACT IS AWARDED TO LINDE

△ Linde Co., Div. of Union Carbide Corp., has been awarded a contract to supply 350-tons-per-day of high-purity oxygen for Great Lakes Steel Corp.'s operations at Ecorse, Mich. The bulk of the new supply will serve the plant's new basic oxygen converter shops, scheduled for completion next year.

The present 500-tons-per-day oxygen plant was put into operation by Linde last year to meet Great Lakes Steel's fast-growing requirements. Most of the current oxygen production is being used in open hearth furnaces which were recently converted to oxygen-lancing techniques as part of the steel company's modernization program. Fifteen of the company's 17 open hearths have now been enlarged and equipped for oxygen lancing.

## MESTA WILL FURNISH NEW COMBINATION MILL

A combination slabbing and plate mill will be designed and manufactured by Mesta Machine Co. for installation at the Sheffield Division of Armco Steel Corp. at Houston, Texas.

This combination mill will operate alternately as a 46 in. × 120 in. two-high reversing slabbing mill or a 160 in. four-high reversing plate mill. As a slabbing mill, this installation will roll steel ingots weighing up to 70,000 lb into slabs $3\frac{1}{2}$ in. to 14 in. thick and 30 in. to 68 in. wide. When the mill completes its scheduled rolling of slabs, the two-high roll assembly will be replaced with a four-high plate mill roll assembly. As a plate mill it will roll steel slabs into plates 0.180 in. to 3 in. thick and 50 in. to 155 in. wide. Tapered neck oil bearings will

Outstanding feature of this mill is the arrangement of the slabbing mill and plate mill roll assemblies to fit the same housings on fixed centers. Another feature is the screw-down assembly which controls the roll adjustment. This screw-down arrangement will provide speed for slabbing mill operation and gage control necessary for plate finishing.


ROCKWELL-REPUBLIC

# V-5 gauges combine small size with big-gauge readability

**TRY THIS "CUTOUT TEST"**

For a true demonstration of the readability of Rockwell-Republic V-5 gauges, cut out the actual-size photo at the right. Mount it on any wall or panel board. Step back and see how easily the scale can be read, even from 10 or 12 feet away!

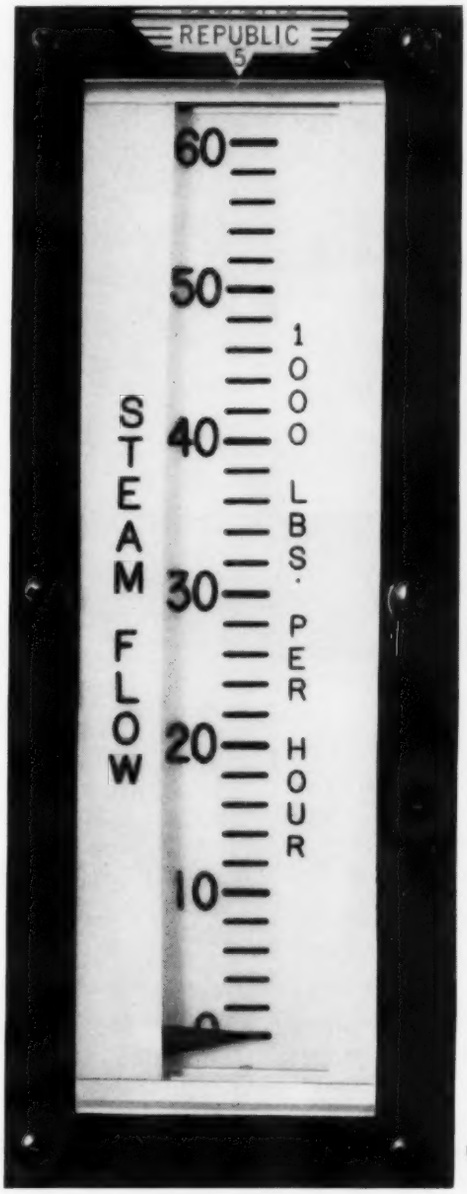
**BIG-GAUGE ACCURACY, TOO**

Compact V-5 gauges are equipped with electric receivers or full sized diaphragms, bellows, and helixes for maximum accuracy and sensitivity. Yet these Rockwell-Republic gauges require one-fourth the panel space needed for standard gauges.

**GROUP MOUNTING INCREASES VERSATILITY**

As many as eight gauges can be grouped in a single mounting case. Types can be mixed to meet individual panel requirements. Mounting is simple, too. Just a panel cutout is required in most cases.

There's a V-5 gauge for almost every process measurement. Mail the coupon today for the 12-page bulletin on these easy-to-read gauges, and for available literature on other Rockwell-Republic instruments, controls, and valves. RF-22

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**Republic Flow Meters Co.** *(Subsidiary of Rockwell Manufacturing Company)*
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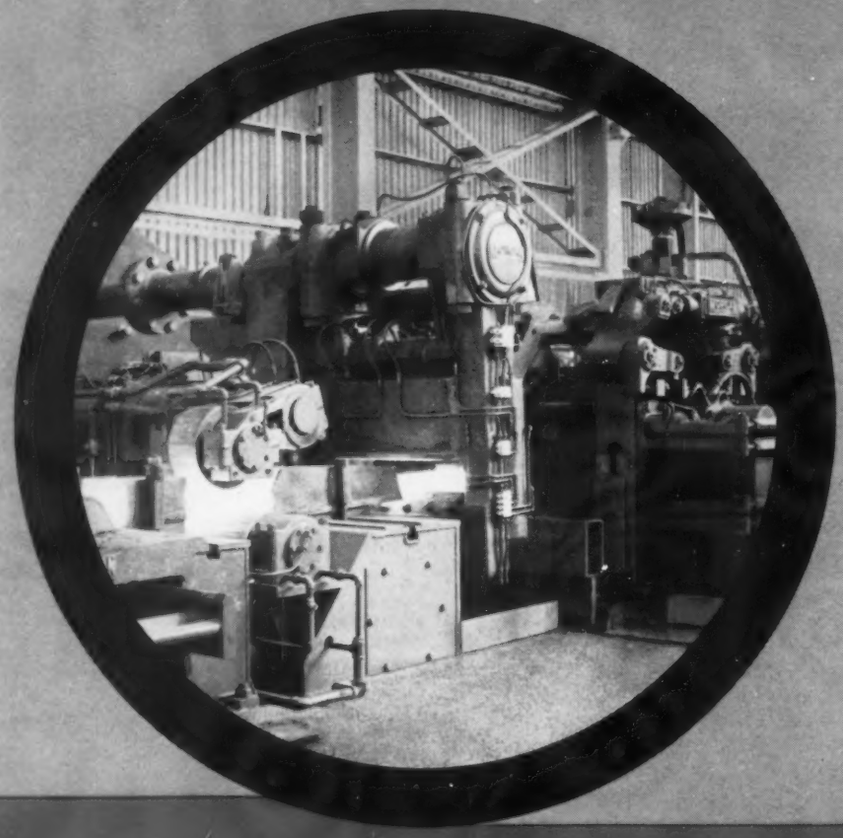

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*management wants* ***profit*** *— millmen need* ***efficiency***

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## has the know-how to build more of <u>each</u> into YOUR MILL

Today's mill must be designed with tomorrow's gauge of operating efficiency and economy foremost in the builder's mind, if it is to compete successfully in the fierce race of the 60's for market advantage.

For each of the critical production problems of the era — roll it faster, roll it at lower cost per ton, roll it to ever higher standards of quality — Morgan's unparalleled backlog of design and construction knowledge provides tangible assurance of effective solutions. Here the essential vigor and vision of engineering concepts are soundly balanced, but never stifled, by a depth of experience unique in the industry — bringing the significant advances to bear early and **profitably** on your individual mill's performance requirements.

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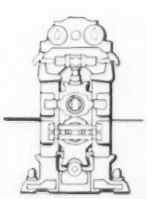
Steel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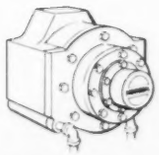
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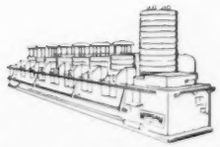
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*THE KEY NAME FOR PROGRESS IN STEEL-MAKING EQUIPMENT*

# SWINDELL

*Multi-Stack and Single-Stack*

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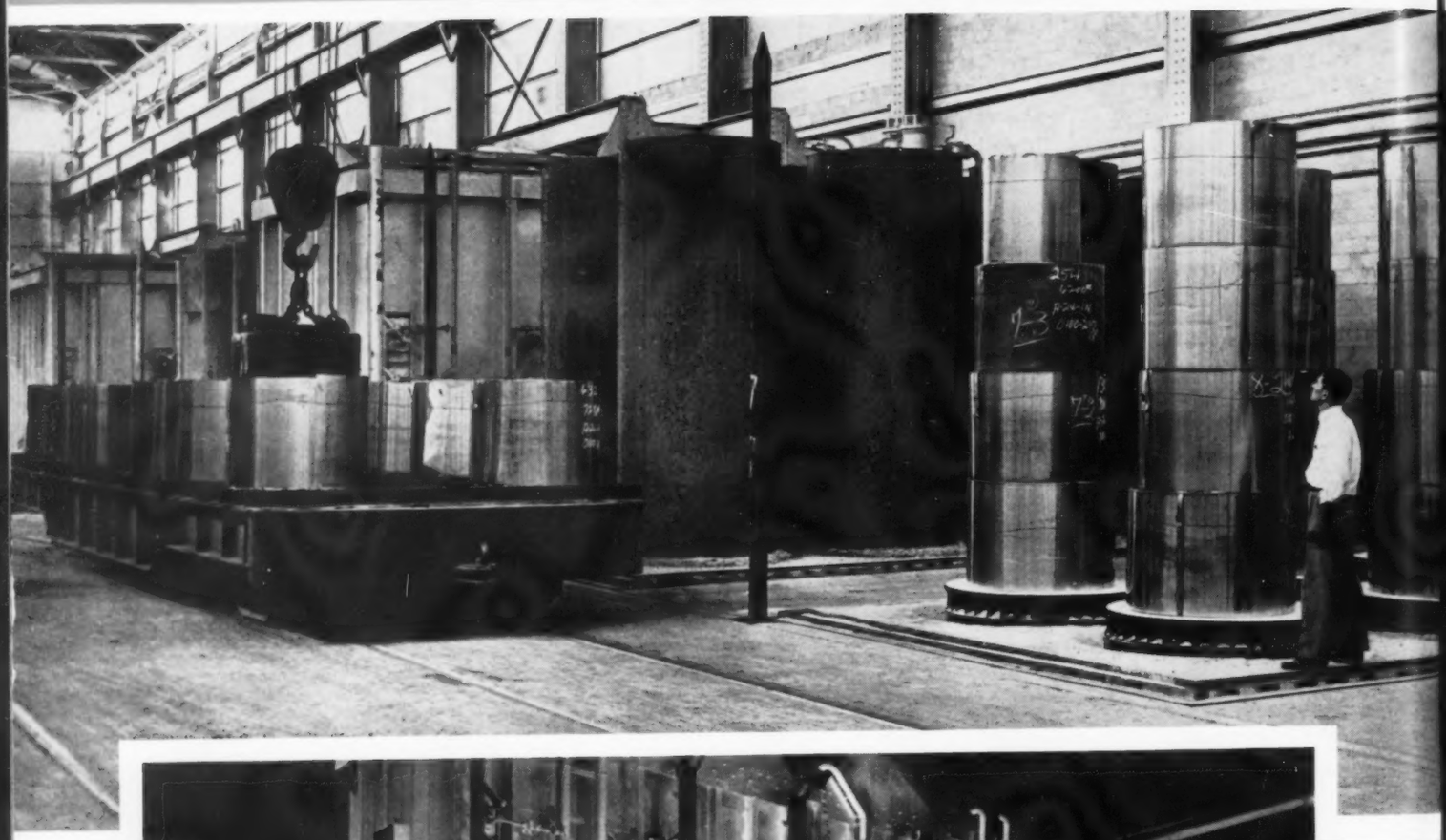
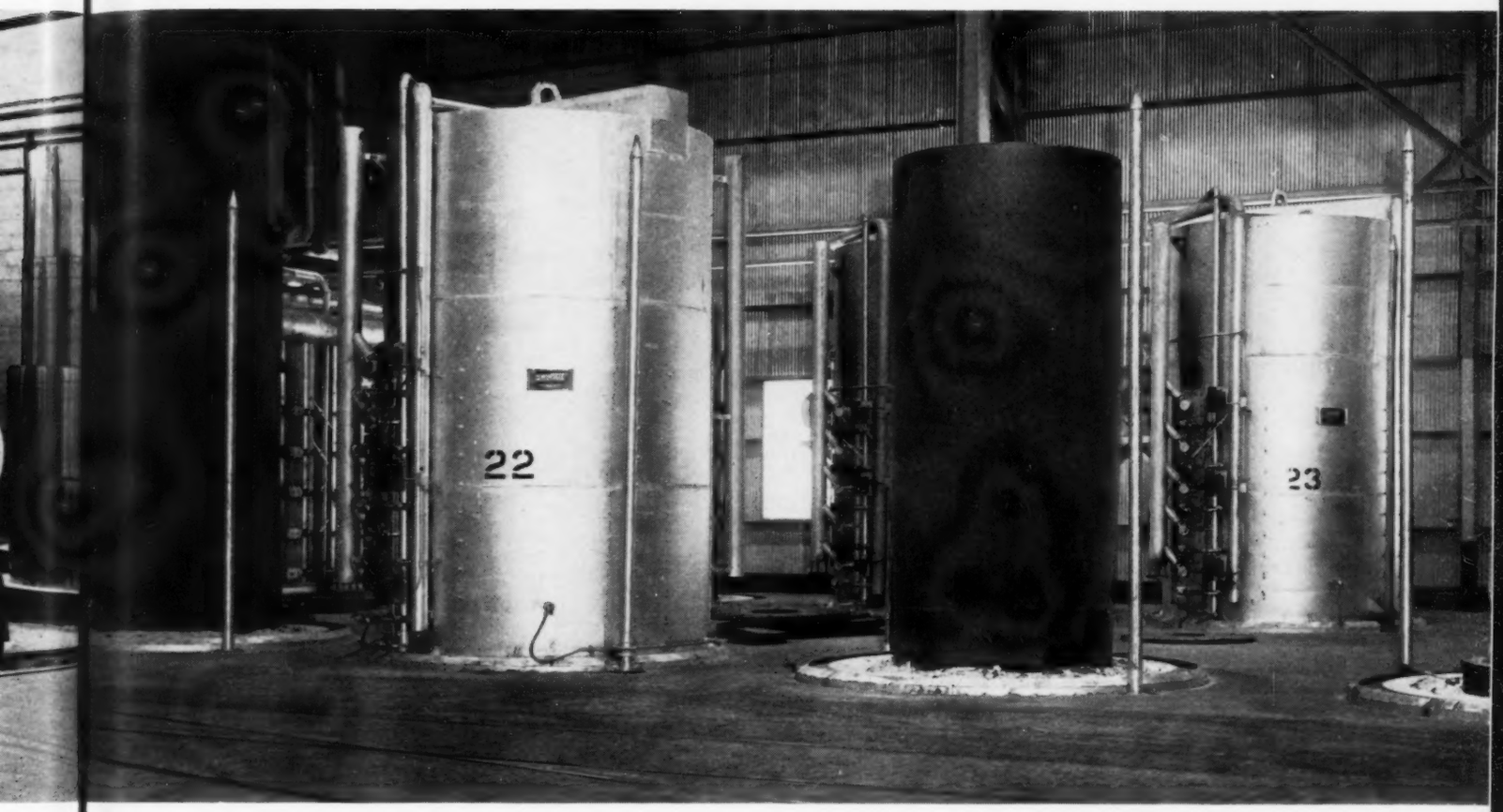


- for better operating efficiency
- and better customer service—

# EQUIP WITH BOTH!




## *Here's why:*

When you equip with *both* Swindell Multi- and Single-Stack Annealing Furnaces in the same shop, you profit!

- You render more effective service to your customers because better equipment flexibility enables you to handle efficiently a greater variety of jobs.
- Additional efficiency is gained because operating techniques and procedures are similar for both types.
- You save in parts inventory and maintenance because burners, load bases, inner covers and other major components are interchangeable throughout.

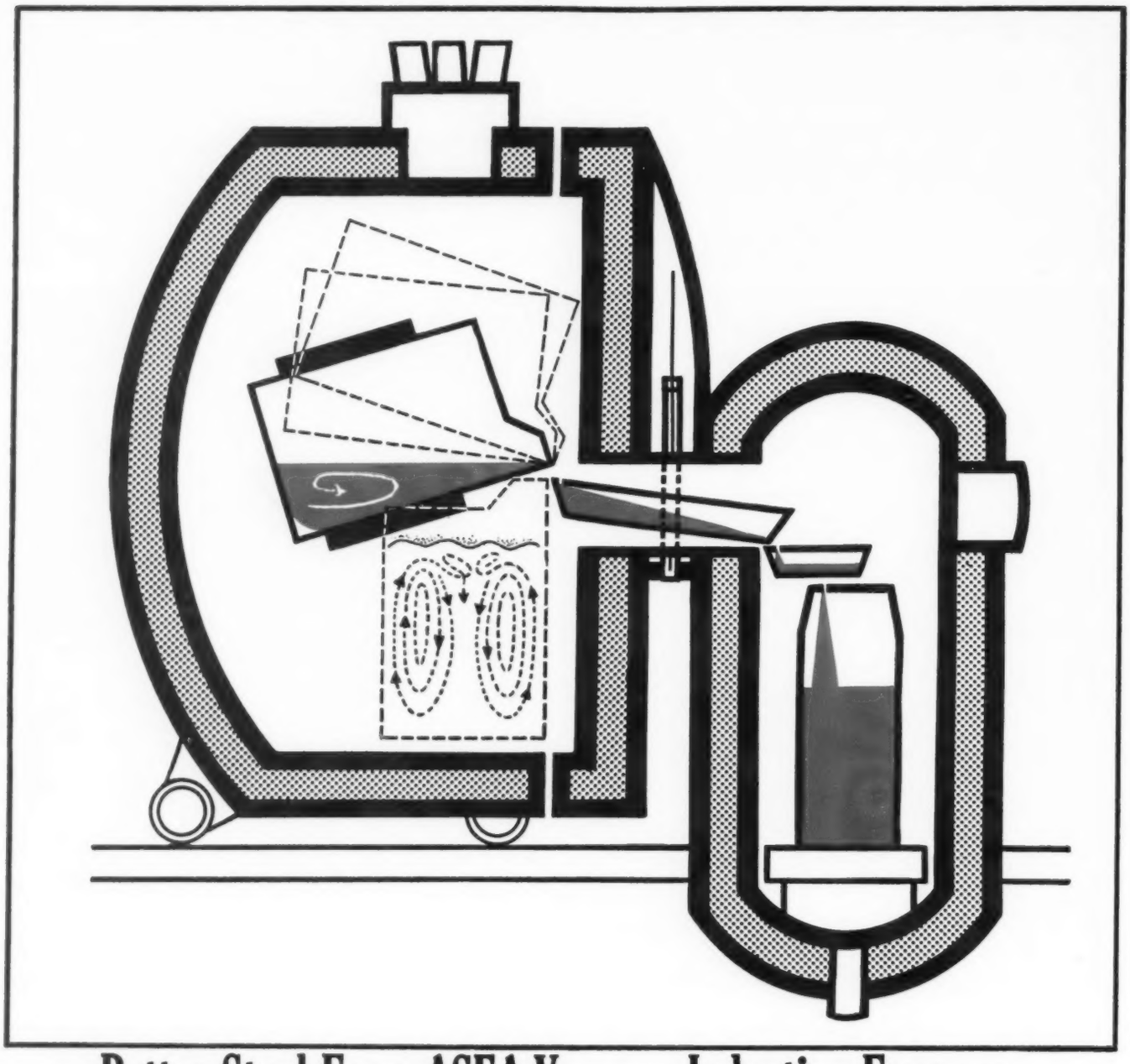
*A SWINDELL-DRESSLER engineer will be pleased to provide further information!*

**SWINDELL-DRESSLER Corporation**

DESIGNERS AND BUILDERS OF MODERN INDUSTRIAL FURNACES

PITTSBURGH 30, PA.

SUBSIDIARY OF PULLMAN INCORPORATED



# Better Steel From ASEA Vacuum Induction Furnaces

U.S. installation of 1100 kW, 5000 lbs. ASEA High Vacuum Furnace. Front View.

Induction melting in vacuum makes steel of high heat resistance, increased fatigue strength and higher yield points. In High Vacuum melting, only ASEA offers all the following advantages: ■ Accurate composition control of melt. ■ Poly-phase, low-frequency Induction Stirring increases homogeneity and purity of melt without temperature increase. ■ Accurate Temperature Control throughout process. ■ Reduced Degassing Time increases steel production. ASEA builds induction furnaces for vacuum melting up to 5,000 lbs. for air melting to 55,000 lbs. ASEA—one organization manufacturing and marketing all electrical and mechanical furnace equipment. Write for folder:

**ASEA**

**ELECTRIC INC.**

500 Fifth Ave., New York 36, N. Y.

# Here's a Bearings, Inc. survey that is saving our customer "endless hours"*

A letter from our customer, Mr. D. G. Shanks, Service Superintendent, Dundee Cement Company, Dundee, Michigan, tells the story far better than we ever could! We quote Mr. Shanks:

"Having received your manuals, which bear the results of your plant wide survey, it is my pleasure to offer the following comments.

"Needless to say, we at Dundee feel you have performed a service, from which we will enjoy benefits for many years to come. The manual is the most comprehensive and complete compilation of important bearing and seal data I have ever seen. *Endless hours of time will be saved in years to come by virtue of your application of our IBM numbers to the manual and its simple cross-reference to the bearing identification. Having the book indexed to our flow system further simplifies its use.

"We recall the many days your men labored climbing over machinery, collecting information and the problems they encountered in obtaining all the bearing specifications.

"Summing it up, we say — splendid job, and many thanks."

THIS COULD HAPPEN TO YOU! Call the branch nearest you and talk it over with one of our experienced bearing engineers.

*Providing bearing service*

*in the North* ➤ **BEARINGS, INC.**

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# Can you get more wear from your shear knives?

# A·S·K for the answer!

Should your shear knives last longer? Could the cuts be more uniform and precise? Could the cost be lower? Get the answers from A.S.K.!

A.S.K. stands for American Shear Knife Company, the steel industry's leading authority on shear knife operation and production.

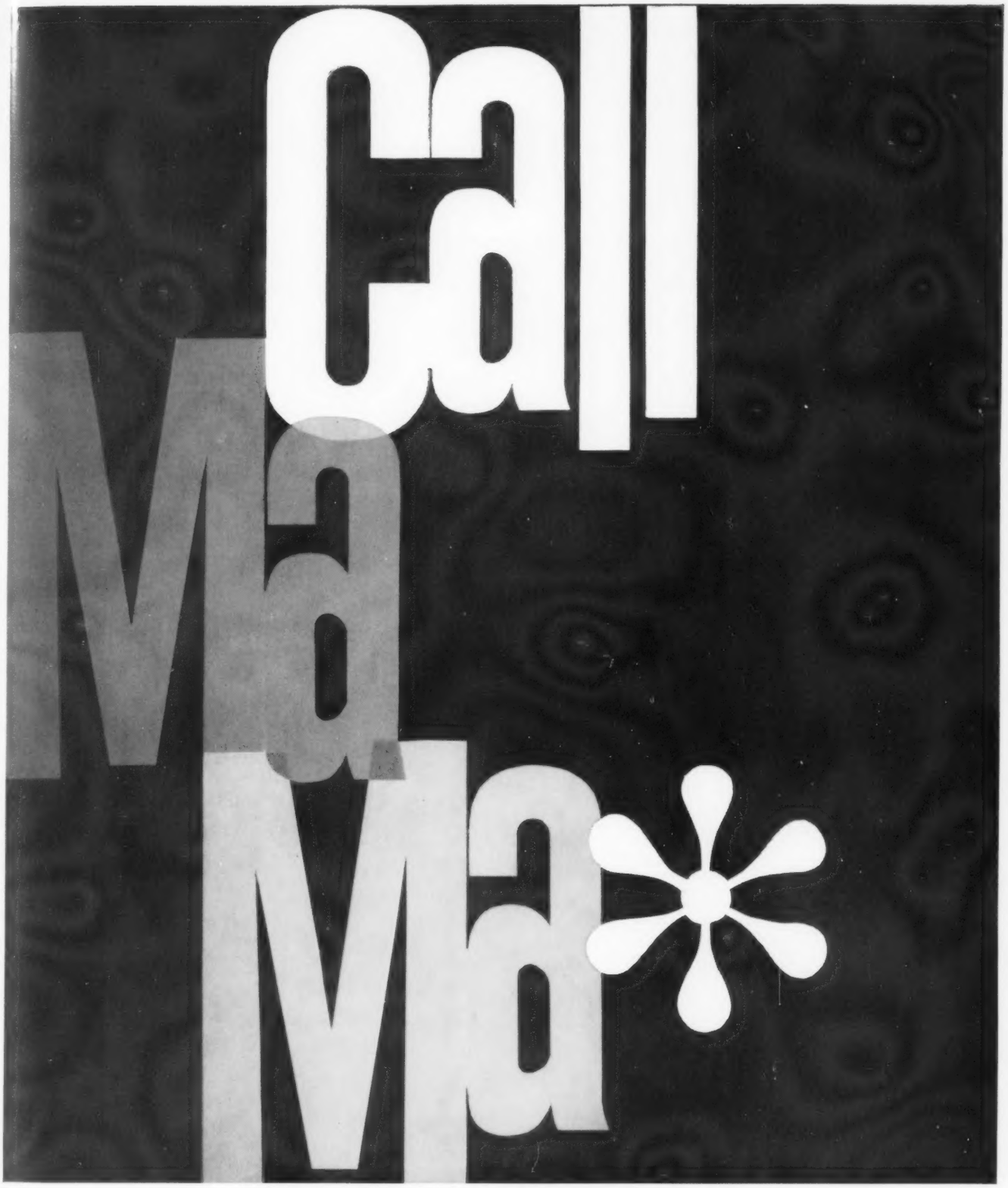
More than 90% of the nation's rolling mills call upon A.S.K. engineers (stationed in most key cities) to survey problems of knife life, cutting quality and operational costs. A.S.K. draws upon years of research in conjunction with top steel mill laboratories to select proper alloys and apply correct techniques in the heat treatment and precision machining of knives. It is this "custom" procedure that makes most A.S.K. knives last up to twice as long, give uniform precise cuts and reduce maintenance and replacement costs.

**FREE SURVEY**—Join the leading companies* who have asked A.S.K. to survey their metal-shearing operations. At no cost or obligation, A.S.K. will send an engineer to your plant to analyze your problems and make cost-cutting suggestions. Just write to American Shear Knife Company, Homestead, Pennsylvania.

**A·S·K**

**AMERICAN SHEAR KNIFE**

**names supplied on request*




*MAchinery-MAintenance Division of CORONADO STEEL COMPANY builds original, replacement and spare parts for Mill-Type equipment. MA MA is ready to help you on any parts problem. MA MA reliability and know-how saves you money and insures fast delivery. We ask only for the opportunity to bid . . . from your blueprints . . . on your next parts problem. Call MA MA . . . next time!

**CORONADO STEEL COMPANY** MACHINERY-MAINTENANCE DIVISION
WEST COMMERCE AND NORTH AVENUE • AREA CODE 216 • RIVERSIDE 7-4436 • YOUNGSTOWN 3, OHIO

# Down go back-up roll costs with

ith

## USS Quality Forged Sleeves

Pictured above is James S. Rennick, a metallurgist with twenty years' experience in the Forgings Division of U. S. Steel. Jim specifies composition, heat treatment, and other processing procedures essential to the production of assemblies as shown in the main picture—a back-up roll that will be used in the cold reduction tin mill at U. S. Steel's Gary, Indiana, plant.

This job points up a curious situation: U. S. Steel is one of the country's leading manufacturers of rolls, and also one of the biggest *users* of rolls . . . a double reason to perfect their performance and reduce their cost . . . just as we did here.

We had to replace a worn, cast steel back-up roll. Rather than replace the entire roll, we machined the face of the roll and shrunk on a *forged* steel sleeve. For back-up rolls like this one, 42" O.D. and larger, this method of sleeving is much less expensive than buying a complete new roll. One arbor can be used for several forged sleeves. A forged sleeve has a hard, wear-resistant surface and is highly resistant to spalling.

Also, the sleeve is purposely produced with a softer bore to develop a desirable stress pattern, and to provide maximum gripping between the arbor and sleeve after assembly.

There is a good possibility that we can help reduce *your* roll costs. Write or call the United States Steel Office nearest you, or United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation, Pittsburgh • Columbia-Geneva Steel, San Francisco • Tennessee Coal & Iron, Fairfield, Alabama • United States Steel Export Company

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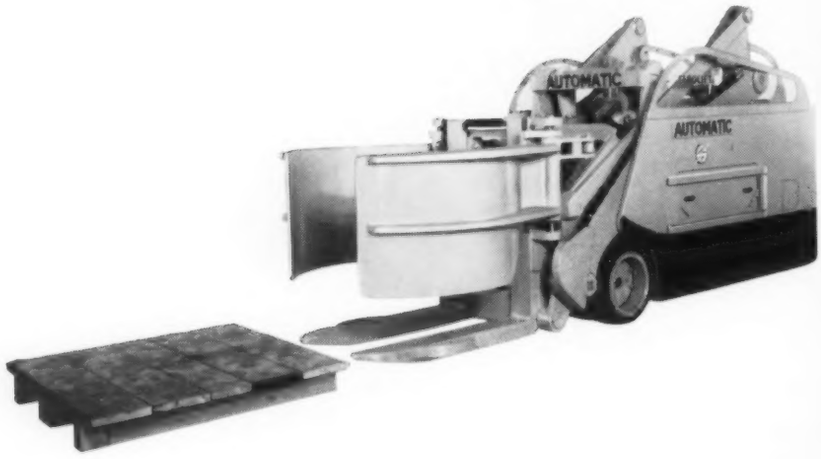
USS

TRADEMARK

Elbolift first picks up pallet.




# NEW AUTOMATIC® Mobile Coil Up-Ender

*handles tin plate with a feather touch*

Now you can handle tin plate more efficiently – without damage to this light gauge material. AUTOMATIC has engineered a unique new attachment for the Elbolift heavy duty truck that up-ends and palletizes coils *anywhere* in the plant. In addition to eliminating damage claims that irritate both your customers and your production people, the truck gives you extra flexibility in your handling operations. The Elbolift can be used for additional handling jobs such as loading coils onto trucks or stacking them into storage three high.

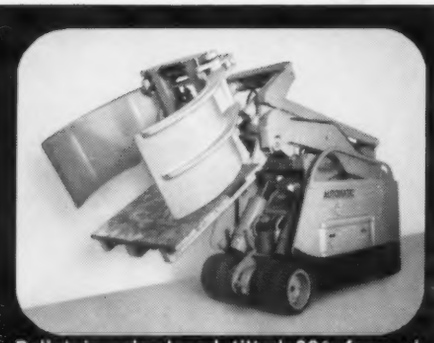
With the up-ender attachment, the Elbolift is available in capacities through 20,000 lbs. Other models available in capacities of 12,000 through 25,000 lbs. Write for up-ender details and for brochure "Heavy Duty Trucks Facts and Factors."

**AUTOMATIC**

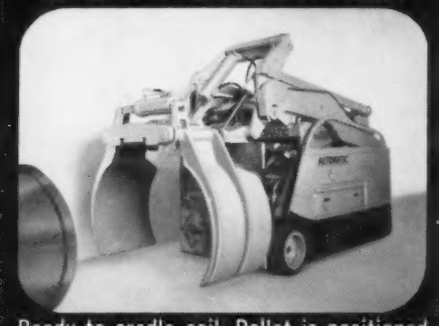
**AUTOMATIC TRANSPORTATION COMPANY**

*Division of The Yale and Towne Manufacturing Company*

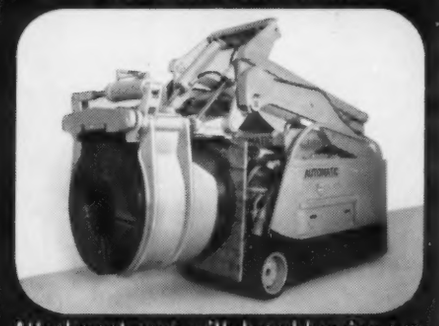
47 W. 87th Street, Dept. D1, Chicago 20, Illinois



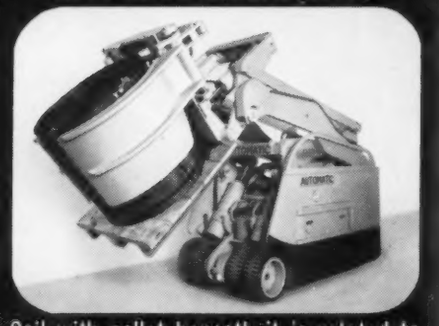
Pallet is raised and tilted 90° forward. Springs on forks hold pallet in place.



Ready to cradle coil. Pallet is positioned behind coil cradle arms.



Attachment arms with broad bearing surface cradle coil, prevent damage.



Coil with pallet beneath it is rotated to horizontal position.

Ready to strap and load onto flat bed truck or into storage.

# Publication Service...

April, 1961

### (1) Thermal Insulation Catalog

Thermal insulations for all types of commercial and industrial requirements are described in a 64-page catalog published by Johns-Manville Corp. This catalog contains six complete sections, each devoted to a specialized group of thermal insulations. These include industrial and high temperature; plumbing, heating, and air conditioning; refrigeration; insulating firebrick and refractories; finishes and weatherproofing materials; and miscellaneous insulations. Three new J-M products, Micro-Bar, Oil-Free Spun Banroc Loose, and Ris-A-Sleev are included, along with more complete data on several older products. Information on each product consists of an application photo, description, available forms or types, advantages to users, and detailed specification data. The type of insulation and its temperature limit are prominently displayed for each product, to facilitate rapid location of pertinent data. (Catalog IN-244A)

### (2) Limit Switches

A new 12-page bulletin describes General Electric Co.'s line of limit switches for automatic pilot control, and includes an application guide, a short section on limit switch terminology, and selection and installation guides. The bulletin discusses typical applications of lever, leverless and rotating cam and limit switches, as well as tripping forces involved for activation of each switch. Photo of each model is shown along with cutaway photo and callouts. Diagrams give typical dimensions of each model. (Bulletin GEA-7312)

### (3) Material Weighing on Conveyer Belt

The Pneumatic Integrator Model PDWH-T and its application to the problem of weighing material being transported on a conveyor belt, is described in a bulletin issued by B-I-F Industries, Inc. The integrator multiplies belt travel with belt loading to produce direct readout of the true weight being conveyed over the weighing section. The bulletin includes an illustration of the integrator, together with dimensional drawings, accessory listing and other descriptive material. (Bulletin Ref. No. 550.20-2)

### (4) Bonded Mullite Refractories

The Chas. Taylor Sons Co. has published an 8-page bulletin describing "TAMUL" bonded mullite refractories made of synthetic mullite. The bulletin describes and illustrates "TAMUL" applications in blast furnaces and blast furnace stoves, hot metal mixers and ladle cars, direct arc furnaces and in other types of heating furnaces. Chemical and physical properties of the refractory are tabulated. (Bulletin No. 322)

### (5) Motodrive Catalog

Now available from Reliance Electric & Engineering Co. is an 88-page publication covering the complete line of Reeves Vari-Speed Motodrives, ¼ through 40 hp. Data includes full rating tables, with new additional output speeds. Dimension diagrams and charts for over 100 different assemblies, higher overhung load and new controls, are contained. (Catalog G-100)

## You Can Obtain . . .

*. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.*

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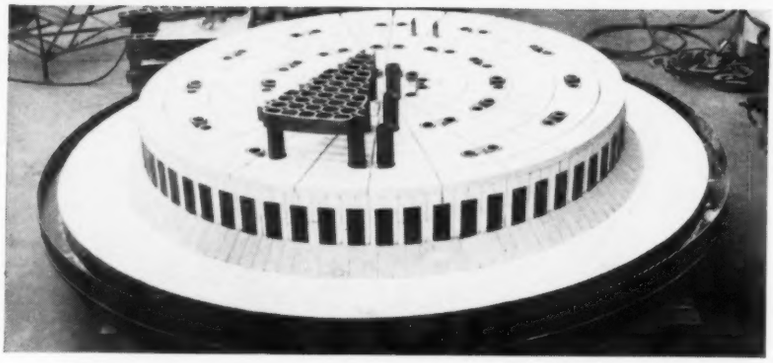
# New Alloy Supertherm* proves itself in 2300 degree fahrenheit brazing furnace



Supertherm hearth grid segment during furnace construction.

In a brazing furnace for the thrust chambers of rocket engines at Rocketdyne Division of North American Aviation, Inc., Canoga Park, Cal., a Supertherm furnace hearth grid assembly is operating at a temperature of 2300° F. The grid in a furnace built by the General Electric Company's Industrial Heating Department at Shelbyville, Ind., supports the engine parts during a brazing cycle of from five to eight hours with a maximum temperature of 2300° F. At this extreme temperature and under severe conditions of thermal fatigue created by the brazing cycle, *the Supertherm grid has performed successfully over one year.*

Supertherm is Electro-Alloys' new alloy for the 1800 to 2300 degree fahrenheit range. The composition of Supertherm is 26% chromium, 35% nickel, and is strengthened and stabilized with cobalt and tungsten. For technical information about the composition, physical and high temperature properties of Supertherm, fill out and return the coupon or contact your local Electro-Alloys representative.

*Supertherm is a patented alloy.

Electro-Alloys Division
3034 Taylor Street, Elyria, Ohio
Please send technical information on SUPERTHERM.

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State____

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION · Elyria, Ohio

# RELIANCE SYSTEMS ENGINEERS SOLVED THE PROBLEM BEFORE THE ANSWER WAS BUILT

It works precisely, as they said it would.

What you see is the source of D-c. power for a dual-purpose cold mill . . . Reliance motors, generators and mill controls. What you don't see, but what the customer gets, is extreme accuracy and smooth, economical operation, from Reliance Systems Engineering.

The cold mill itself uses four rolls for cold reducing . . . two rolls for tempering and finishing. A 250 hp. Reliance D-c. motor powers the mill and can be quickly coupled to either set of rolls, depending on the operation selected. Utilization of full motor speed range produces a maximum of 300 feet per minute on 8″ or 20″ rolls. The reel is driven by a 100 hp. D-c. motor with two VSR regulators, one to match the speed of the mill—the other to maintain tension. Reliance Engineers determined the *right* regulators to use and *how* to use them, saving this customer equipment and operating costs.

Reliance Systems Engineers can apply their talents to your systems operations—in advance—give you the thinking and the products that do the job you want and need. Can we help you?

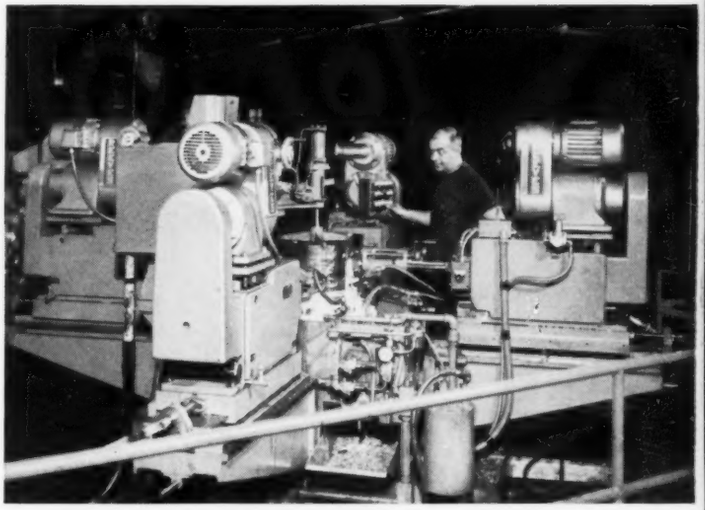
BUILDERS OF THE TOOLS OF AUTOMATION

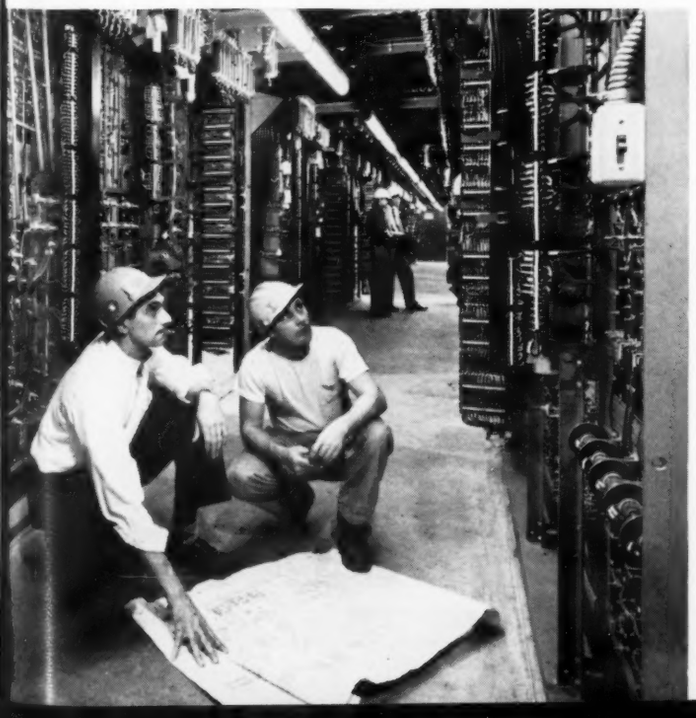
A-1682

**ONE SELF-CONTAINED, COMPACT POWER PACKAGE. This MASTER GEARMOTOR** has been operating outdoors for 5 years regardless of weather. It has no exposed high speed couplings, no V-belts, chains or sprockets. Engineering and assembly costs are reduced. You can simplify installations and save space with vertical, horizontal and flange mountings; output shaft over, under, left or right. Ratings 1/8 to 125 hp. in right angle, parallel or in combination. Right angle ratios are available up to 96:1; parallel 120:1. Bulletin E-2409.

**CONTOUR EPOXY-COATED TO ELIMINATE ENCAPSULATION CRACKING. New RELIANCE ENCAPSULATED MOTOR** . . . gives you positive protection from dust, dirt, acid and water. Unlike other heavy molded coatings, stator windings are vacuum-impregnated with epoxy resin at a uniform thickness, follow the contour of the windings. You get maximum flexibility, tensile and bond strength, plus quicker cooling . . . all vital to superior motor performance. Bulletin B-2108.

**INFINITELY VARIABLE OUTPUT SPEEDS AT LOW COST. REEVES MOTODRIVES,** shown here powering this 4-position drilling and boring machine, are used extensively for hundreds of production needs. Horsepower ratings from ¼ to 40, speeds from 1.71 to 4660 rpm. Speed variation ranges from 2:1 to 10:1. Available in hundreds of space-saving assemblies . . . with manual, remote or automatic process control (Airtrol). Bulletin M-592.

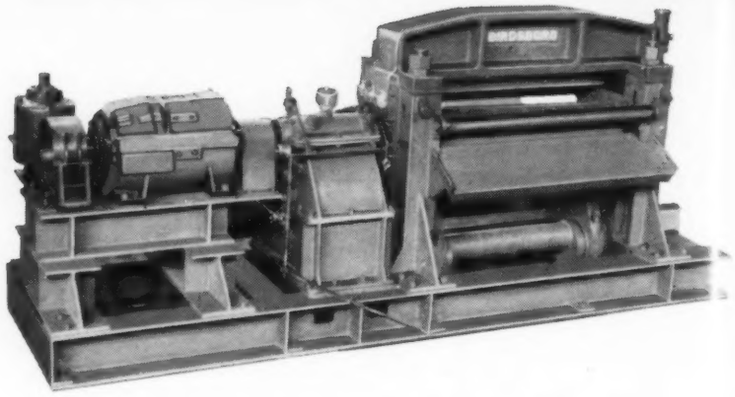




**TOTAL SERVICE** is an integral part of every Reliance product, from engineering and start-up assistance to maintenance and renewal parts. The photo shown here is typical of a Reliance Service Engineer's on-the-job availability—for maintenance and consultation on knotty problems. Every Reliance Sales Engineering Office and Distribution Center—nationwide—gives you the attention and experience necessary to assure the top performance you expect from the Reliance equipment you buy.

**RELIANCE** ELECTRIC AND ENGINEERING CO.

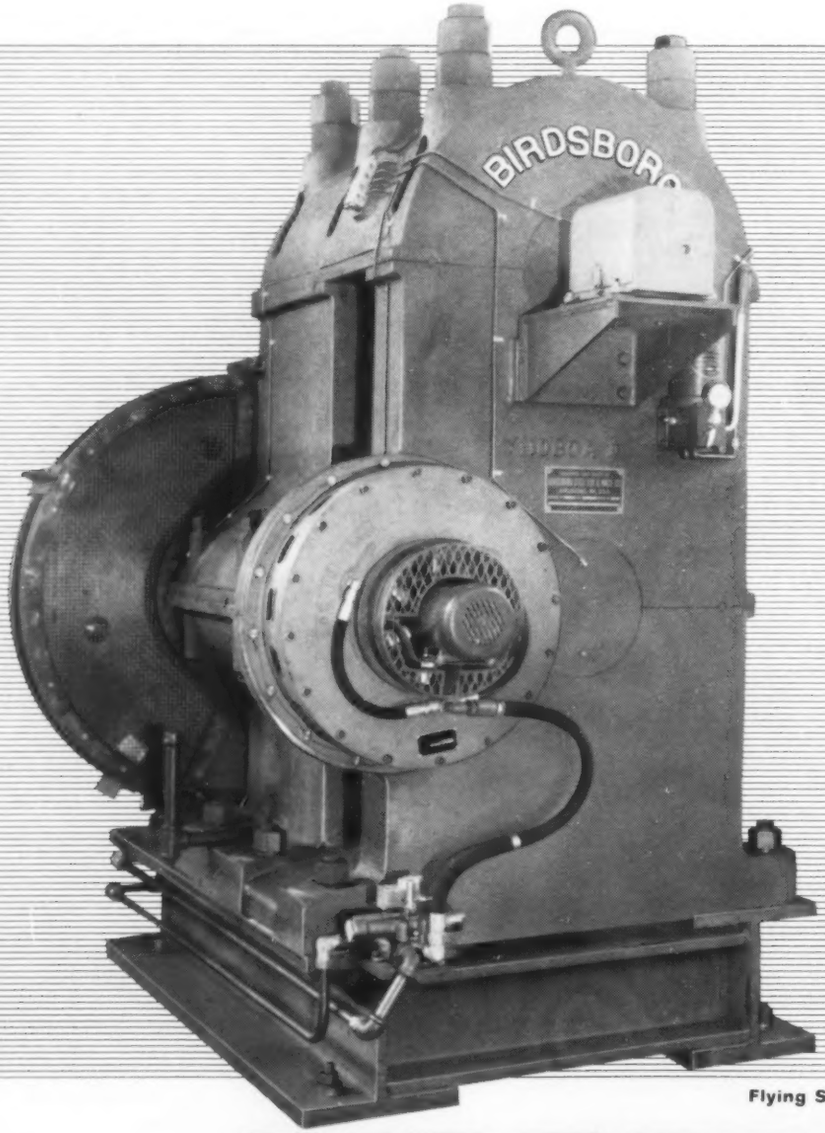
DEPT. 114A CLEVELAND 17, OHIO • Canadian Division: Toronto, Ont.



# BIRDSBORO

## *Customized Shear Designs pay off in higher productivity*

• Like any other key piece of mill equipment, shears have been given a lot of BIRDSBORO's attention in recent years. As a result, many innovations are available to the mill operator that can eliminate former problems and provide a finer product at a lower cost. BIRDSBORO's shear case history book is a full one. In it you can see a number of firsts, some of them applicable to your operation. The BIRDSBORO representative can help apply creative engineering to your mill. *Sales Department, Engineering Department and Mfg. Plant:* Birdsboro, Pa., *District Office:* Pittsburgh, Pa.




Flying Shear by BIRDSBORO

MM73-19

**BIRDSBORO**

CORPORATION BIRDSBORO, PENNA.

STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • ROLLS • ELECTRIC STEEL CASTINGS: Carbon, Low Alloy and STAINLESS STEEL

# Personnel News...

**Walter S. Winiarczyk** has been appointed general superintendent of The Colorado Fuel and Iron Corp.'s Buffalo plant. Mr. Winiarczyk had been serving as maintenance superintendent, having joined CF&I in 1947 as a member of the Engineering Department. At the same time, **Harold A. Smith** was appointed superintendent of the Mechanical Department at the Buffalo plant. Mr. Smith has been serving as master mechanic at the blast furnace area since 1944, having joined CF&I's maintenance force in 1936.

**Charles T. Fettel** has been appointed superintendent of the blooming, slabbing, structural mills and soaking pits, Kaiser Steel Corp., Fontana, Calif. He came to Kaiser Steel in 1946 as foreman in cold drawing and advanced to general foreman. He moved to general foreman of the billet yards and then general foreman of the structural mill. In 1953 he was appointed assistant superintendent of the merchant mill. Five years later he became superintendent of that department, the position he held prior to his present appointment.

**Edgar M. Herold** has been appointed superintendent of the merchant-skelp mill at Kaiser Steel Corp.'s Fontana plant. He came to Kaiser Steel in 1957 as assistant superintendent of the roll shop, the position he held prior to his new appointment. Mr. Herold was formerly superintendent of the 10, 12 and 14-in. rolling mills at Crucible Steel Co. of America in Midland, Pa. Prior to that he was with United States Steel Corp. **Wayne G. Crutchfield** succeeds Mr. Herold as assistant superintendent of the roll shop. Mr. Crutchfield joined Kaiser Steel in 1951 as a production assistant. In 1955 he was appointed a shift foreman in the roll shop. A year later, he became a roll designer and in 1957 was named foreman in the plate and 86-in. mill roll shop, the position he held prior to his present appointment.

**Anthony J. Toth** has been appointed general foreman of The Colorado Fuel and Iron Corp.'s 25-in. mill at Pueblo, Colo. Mr. Toth has been serving as turn foreman since 1953, having joined CF&I in 1946 as hot saw operator.

**Robert E. Frankenberg** has been appointed service metallurgist at the Louisville, Ohio, plant of Jones & Laughlin Steel Corp.'s Stainless and Strip Division. Mr. Frankenberg was formerly assistant chief metallurgist at the York Division of Borg-Warner.

**James E. Braunberns** and **John W. Rickey** have been named as assistants to the chief metallurgist at the Lackawanna, N. Y., plant of Bethlehem Steel Co. Mr. Braunberns is a 1935 member of the company's loop training course and was assigned to Lackawanna's Metallurgical Department. In 1936 he was made an assistant metallurgist, in 1950 chief metallographist and in 1956 metallurgical supervisor. Mr. Rickey was also a member of the loop course, being assigned to Lackawanna in 1937. He was appointed an assistant metallurgist in 1946, a contact metallurgist in 1952, and chief metallographist in 1956.

**John T. McHugh** was appointed general plant manager at Precision Drawn Steel Co., Pennsauken, N. J. He was formerly division superintendent of wire and wire products at the Donora, Pa., plant of the American Steel & Wire Division of U. S. Steel Corp.

**Boris E. Yarotsky** has been appointed assistant to the vice president—operations for administration, a newly-created position with Crucible Steel Co. of America. Formerly manager of personnel services, Mr. Yarotsky joined Crucible in 1955 as assistant to the director of research and development. He was appointed manager of organization planning in 1957 and manager of personnel services last year.

**William A. Bringman** was named assistant superintendent of the Masonry Department at Kaiser Steel Corp.'s Fontana plant. Mr. Bringman joined Kaiser Steel last year as masonry engineer. Previously he was

W. S. WINIARCZYK

H. A. SMITH

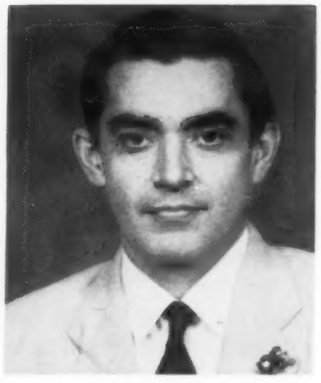
C. T. FETTEL

E. M. HEROLD

G. J. VAN FOSSEN

J. R. LOCKARD

J. T. PITTS



K. S. KUKA

employed by Great Lakes Steel Corp. as a practice engineer in masonry from 1957 to 1960. From 1951 to 1957 he advanced from trainee to hot strip mill foreman at Ford Motor Co.'s Steel Division.

**Grant J. Van Fossen** was named superintendent, 110-in. rolling mill—30-in. hot strip mill, Alan Wood Steel Co., and **Joseph L. O'Hara** was named assistant superintendent. Mr. Van Fossen, who joined Alan Wood in 1937, has served as superintendent, 30-in. hot strip mill since 1951. Mr. O'Hara joined Alan Wood in 1940 and has served in various positions in the blooming and strip mills.

**James R. Lockard** has been appointed master mason for The Colorado Fuel and Iron Corp.'s Pueblo plant. Mr. Lockard has been general foreman for furnace rebuilding and maintenance since 1958, having served previously as assistant mason foreman of the open hearth, fuel engineer and instrument repairman in the Combustion Department. He first joined CF&I as a helper in the machine shop in 1941. **John J. Neelan** succeeds Mr. Lockard as general foreman, furnace rebuilding and maintenance. Mr. Neelan has been serving as assistant general foreman since 1958. He had been in the open hearth previously, having joined CF&I in 1957 in the Garage Department of the Pueblo plant.

**J. T. Pitts** was named sales manager of the Brown Instruments Division, Minneapolis-Honeywell Regulator Co. He succeeds **J. A. Robinson,** who joins the company's six-division Industrial Products Group to co-ordinate expanding activities in the metals producing areas. Most recently Mr. Pitts was southwest regional manager. Joining Honeywell in 1945, he held sales posts in Charlotte and Durham, N. C., before going to Houston, where he was branch manager from 1952 to 1958. Mr. Robinson has been with the company since 1929. In his new assignment he will also work closely with Honeywell's Special Systems Division in the development of computer control systems.

**K. S. Kuka,** after 20 years with Tata Iron & Steel Co. Ltd., Jamshedpur, India, where he held the position of deputy chief engineer (plants), is now with M. N. Dastur & Co. Private Ltd., steel plants consulting engineers in India. He is a director and also chief electrical engineer of the firm. He has written numerous technical papers, with several published in the *Iron & Steel Engineer*, several receiving honorable mention for the Kelly Awards. He is also the first non-American to receive a Kelly Award for one of his papers, winning third place for one published in the 1954 Proceedings AISE.

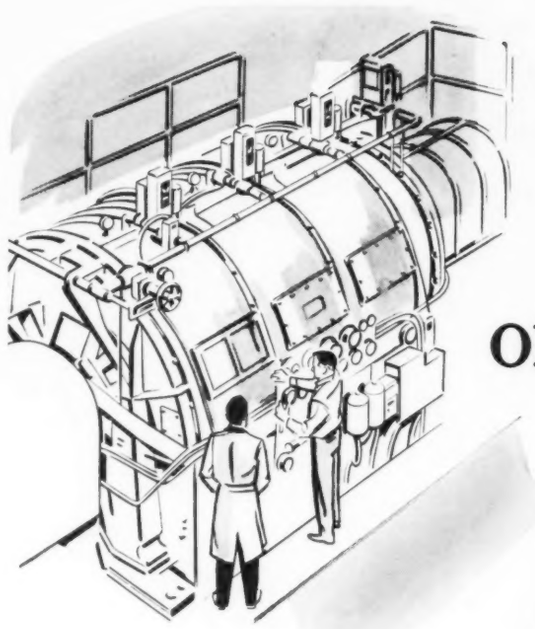
**Walter C. Rueckel** has been appointed vice president of Wilputte Coke Oven Division, Allied Chemical Corp. Dr. Rueckel was formerly associated with Koppers Co., Inc.'s, Engineering and Construction Division, serving as manager of operations, vice president of sales, and vice president and general manager. He was also vice president and manager of sales of Henry J. Kaiser Co.

**Frank C. Senior** has been elected vice president in charge of operations for Strategic Materials Corp. Mr. Senior has been general manager of the company's SUMAC metallurgical plant at Niagara Falls, Ont., since 1958. Prior to joining Strategic Materials, Mr. Senior had been director of development of the Engineering and Construction Division of Koppers Co., Inc., which he joined in 1946. In 1950 he formed his own engineering company and in 1951 he became president of Herman A. Brassert Co., an engineering firm. In 1954 Mr. Senior went to Mexico and formed a company for the Manzanillo steel project.

**Elmer A. Koenig** has been appointed vice president in charge of sales for The Yoder Co. He joined Yoder in 1942 and was appointed to the Sales Department in 1945. He was named assistant sales manager in 1949, sales manager in 1952 and director of sales in 1956. **Eugene L. Mackey** was named vice president in charge of engineering for Yoder. He began his services with

E. A. KOENIG

E. L. MACKEY



# There's more than one kind of Dynamatic service!

Some folks think of "service" as the help you need when something goes wrong. That's important, of course, and Dynamatic supplies it with competent service representatives located in principal cities throughout the United States and Canada. In addition, around-the-clock seven-days-a-week service is available from the factory.

But there's another kind of service that's equally important—the service that starts even before you have purchased Dynamatic speed control equipment. It's being able to sit down with your Dynamatic representative, knowing that he has very likely been up against a problem about the same as yours before; that he has a background gained through years of experience in this specialized field.

Dynamatic service begins with your first inquiry, includes start-up supervision by factory service engineers, and follows through for the life of the equipment.

EATON

DYNAMATIC®

Dynamatic produces Eddy-Current Drives, Couplings, Brakes, and Dynamometers. Also Dyna-torQ Magnetic-Friction Clutches, Brakes, Clutch Brakes, and Clutch Couplings.

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*ORIGINATORS OF EDDY-CURRENT SPEED CONTROL EQUIPMENT*

*THE IDEAL COUPLER*
*FOR INDUSTRIAL HAULAGE*

# SHARON-10A

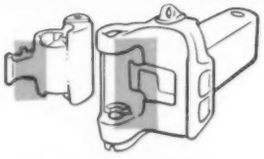
National's Sharon-10A Automatic Couplers are in use throughout the world on industrial cars, mine cars, railroad cars and transit cars. They can be furnished for varying service requirements such as regular top and bottom operation, improved type G side pull, type F side pull, rotary side or rotary bottom operation. For smaller cars not warranting use of the full-size Sharon-10A coupler, they can be furnished in 3/4 size as the Sharon-10 instead of with the full 10A contour.

STEEL CASTINGS Centennial 1861-1961

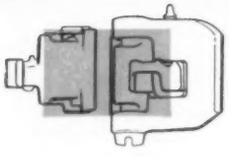
A-1285A

**SHARON-10A • SHARON-10A • SHARON-10A**

**Gives longer service life.** Liberal allowance for wear and distortion.

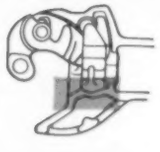


**Has greater buffing strength.** Substantial buffing shoulders in coupler head and knuckle.

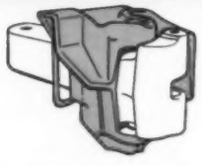


**Has less pulling stress.** Lugs reduce stresses on knuckle pin.

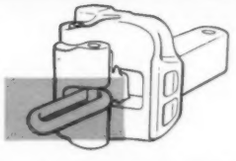
**SHARON-10A • SHARON-10A • SHARON-10A**



**Features secure locking.** V-shaped design stabilizes lock in coupler wall.



**Is protected from molten metal.** Hood protects uncoupling mechanism from metal splash.



**Is versatile.** Can be supplied with slotted or off-set knuckle for use with present link and pin equipment.

GEARED TO PROGRESS P R I MEMBER

## NATIONAL MALLEABLE and STEEL CASTINGS COMPANY

*Established 1868*

*Transportation Products Division*
*Cleveland 6, Ohio*

*International Division Headquarters*
*Cleveland 6, Ohio*

CANADIAN SUBSIDIARY
*National Malleable and Steel Castings Company of Canada, Ltd.*
*Toronto 2-B, Ontario*

COUPLERS • YOKES • DRAFT GEARS • FREIGHT TRUCKS • JOURNAL BOXES
NATIONAL SPEEDLOADER CONTAINER HANDLING SYSTEM

the company in 1935 as draftsman, was named chief draftsman in 1947, assistant chief engineer in 1952 and director of engineering in 1955.

**John J. Hayes** has been named field sales manager of the L. J. Wing Mfg. Co. He has been with Wing since 1954, most recently as manager of the company's New York branch office. **Arnold H. Hansen** succeeds Mr. Hayes in that capacity. Mr. Hansen has been a sales engineer in the New York office since joining Wing in 1948.

**Jack Q. Lewis** was named manager of the Birmingham, Ala., branch of A. P. Green Fire Brick Co. He will continue active management of the Dixie Fire Brick Co., which was merged with Green in 1959.

**Henry A. Bednarski** has been named sales engineer in Basic Incorporated's Furnace Products Division. Mr. Bednarski will be headquartered in the Philadelphia office. He was formerly with U. S. Steel Corp. at South works in Chicago, Ill., as melter and first helper. Since 1956 he has been with Harbison-Walker Refractories Co. as assistant manager, basic sales.

**Theodore S. Savage** was appointed assistant chief engineer, Thermal Transfer Corp. Mr. Savage joined the company as an engineer in 1959.

**William T. Brown** has been named vice president in charge of manufacturing of Philadelphia Gear Corp. He joined the firm in 1934 and has served in the capacities of foreman, plant superintendent and since 1948 as plant manager. At the same time, **Harold O. Kron** was named vice president in charge of engineering. Mr. Kron joined the firm in 1948 and has been serving as chief engineer prior to his appointment.

**Thomas F. Gallagher** has been named general sales manager of The Davis Fire Brick Co. Mr. Gallagher will also act in this capacity for the companies associated with Davis—The Sivad Ceramic Corp., The Ohio Fire Brick Co. and The Cambria Clay Products Co.

**A. F. Boucher** has been named general sales manager by The Lincoln Electric Co. He advances to his new position from assistant general sales manager. Mr. Boucher came to Lincoln in 1936. His first field assignment was in the Cleveland office as a field engineer. In 1939 he was made a district manager and has held this title in Lincoln's Milwaukee and Detroit territories. Mr. Boucher assumes the company's general sales responsibility from **J. S. Roscoe** who will devote full time to special market development assignments.

**Cameron Sevier, Jr.,** was named manager of the eastern sales district, Basic Incorporated. Mr. Sevier has been a sales and service engineer in the eastern office since 1959. Formerly he was assistant superintendent, open hearth and electric furnaces, with Republic Steel Corp. in Gadsden, Ala.

**Robert A. Gordon** has been appointed assistant manager of district sales for Link-Belt Co., with headquarters in the executive offices in Chicago. He will assist in co-ordinating all phases of district office operations. Mr. Gordon joined Link-Belt in 1946, in the Engineering Department of the company's Philadelphia plant. He was subsequently transferred to the Pershing Road plant in Chicago in 1947 as sales engineer. Since 1958, he has been on special assignment at the executive offices.

**Frank W. Trost** has been named to the position of district manager of the Philadelphia sales territory by The Chas. Taylor Sons Co. He joined Taylor in 1950, and after some months in the Cleveland territory, was assigned to the Philadelphia territory, which comprises eastern Pennsylvania, southern New Jersey, Maryland and Washington, D. C.

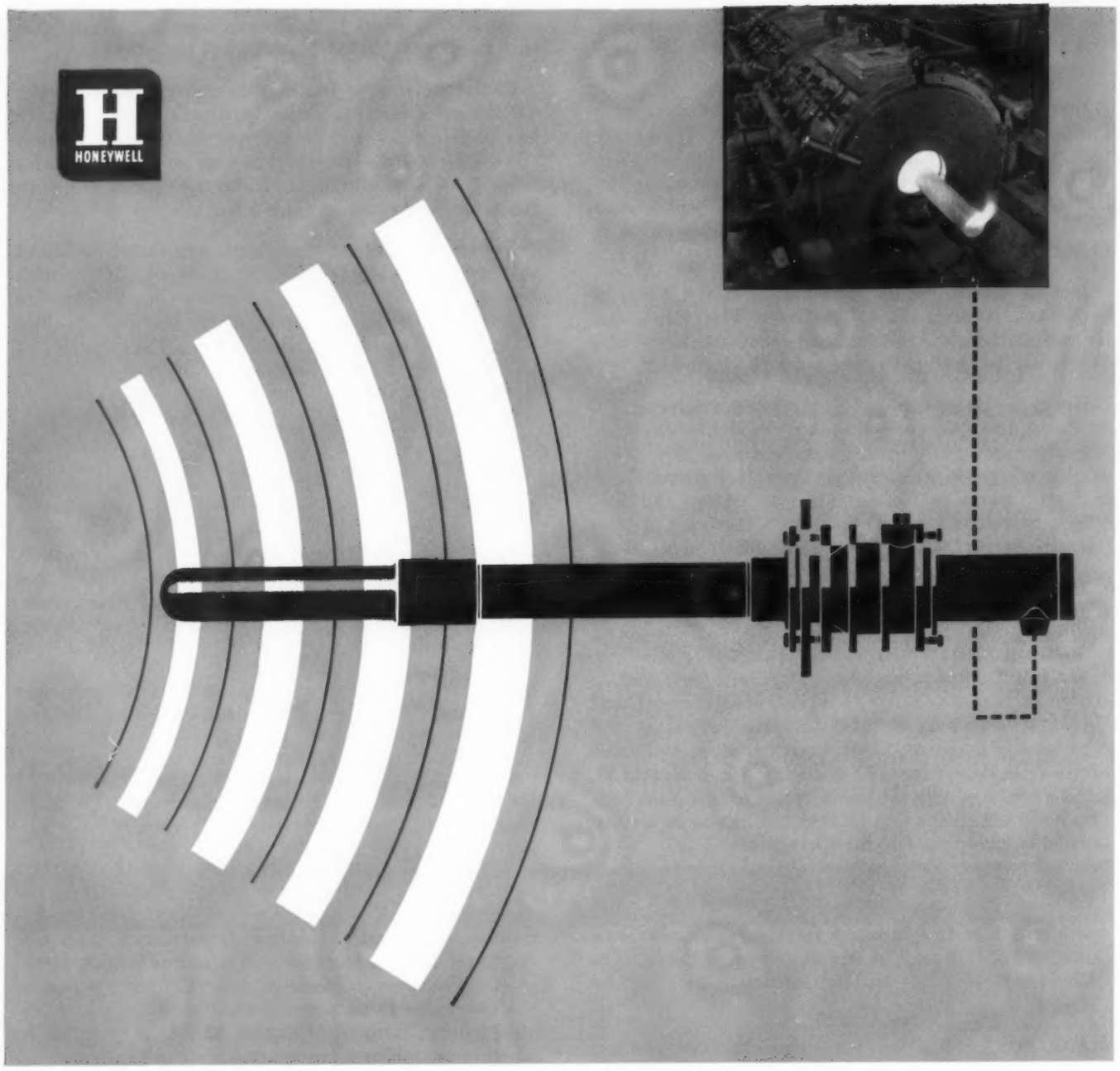
**W. L. Van Winkle** has been appointed sales manager of the Small Diameter Rolls Manufacturing Division of Voss Engineering Co.

**Robert L. Hibbard** has joined Sutton Engineering Co. as staff engineer. He was formerly with Wm. K. Stamets Co., where he served for 27 years.

**Raymond C. Berendsen** has been appointed general manager of a new General Electric Co. industrial process control computer section established by the company's Industry Control Department. The new computer control business will continue to operate at existing facilities in Phoenix, Ariz. Formerly a part of the Computer Department there, this operation is now assigned to Industry Control, the G-E department which manufactures automation control equipment for process industries. Mr. Berendsen was previously manager of advance projects and marketing for the company's Ordnance Department at Pittsfield, Mass.

**B. J. Philibert** has been appointed industry manager for the Pittsburgh Chemical Co.'s Protective Coatings Division. Mr. Philibert was formerly sales representa-

**W. T. BROWN (left)**
**H. O. KRON (center)**
**T. F. GALLAGHER (right)**




**Specify Radiamatic Infrared Detection Systems for dependable, economical temperature measurement and control**

For more than 20 years, Radiamatic Infrared Systems have been giving reliable, accurate service in every area of industrial temperature measurement and control. Over the years, Honeywell has developed special infrared techniques and equipment for a wide range of applications, including soaking pits, kilns, heat treating, induction and forging furnaces.

The key to the high accuracy and low cost of these systems is the Radiamatic Infrared Detector. Available in many different models with a full line of accessories, these detectors measure temperatures from 200°F. up to 7000°F.

For complete information on how Radiamatic Infrared Systems can solve your temperature measurement and control problems, call your nearby Honeywell field engineer. Or write Minneapolis-Honeywell, Wayne and Windrim Aves., Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

**Honeywell**

H First in Control SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

tive for the Protective Coatings Division of Pittsburgh Chemical Co. in the Gulf Coast area.

## *Obituaries*

**D. Frank Carey,** assistant to the superintendent of the Rolling and Finishing Departments at the Pueblo, Colo., plant of The Colorado Fuel and Iron Corp., died February 23. He was 40. He began his association with CF&I as an industrial engineer in 1949 at the Pueblo plant, transferring to the Rolling and Finishing Departments in 1953.

**M. E. Marsh,** assistant vice president in the Operations Division at Wheeling Steel Corp., died March 12. He had been associated with Wheeling Steel since 1929 and had been assistant vice president in charge of factories since 1953.

**William T. Welch,** chairman of the board of the Ajax Flexible Coupling Co. Inc., died March 12. Mr. Welch, with his father, **Dr. C. E. Welch,** was co-founder of Ajax in 1920.

**James S. Ervin,** a director of E. W. Bliss Co., died March 7. He was 75. Mr. Ervin was for many years the president of Mackintosh-Hemphill Co., and became a director and member of the executive committee of E. W. Bliss Co. in 1955 when Mackintosh-Hemphill became a division of Bliss.

**Ralph E. Campbell,** West Coast regional manager for SKF Industries, Inc., died March 16. He was 46. Mr. Campbell formerly served as manager of SKF's Pittsburgh district office.

Chosen for its low maintenance and freedom from past conductor system difficulties, this Ringsdorff Current Conductor System is now an integral part of the great ore bridge at the Lorain Works of U.S. Steel. Ringsdorff Current Conductor Systems are easily adaptable to any normal or special application in American Industry.

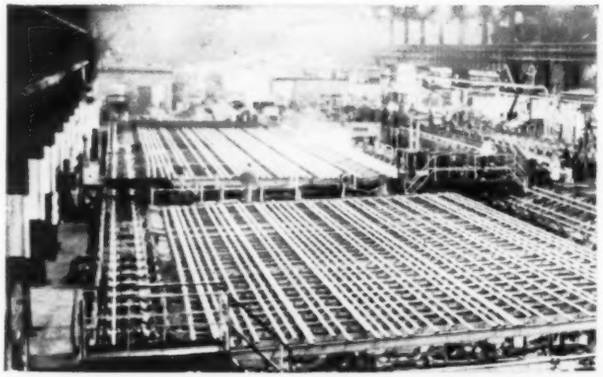
*The Ringsdorff Current Conductor System is now being manufactured in the United States*

**RINGSDORFF CARBON CORPORATION**

P.O. BOX 22 · EAST McKEESPORT, PA. · (PITTSBURGH DISTRICT)

# NORTHEAST/Cooling Beds

## *Another example of component engineering for the automation of the Metals Industry:*



Continuously running Cooling Racks. Each is 220' long by 9'4" wide and consists of 56 strands of chain on 4'6" centers. Stationary channels are placed between chain supports to rotate elements as they cool, to assure a straighter, more uniform product.

The illustrated subject is one of two mechanical Cooling Beds built to handle reinforcing bars automatically and efficiently in a leading Pennsylvania mill.

Designed by a team of Northeast Engineers to perform a specific operation, they are chain-type beds with adjustable speed drives at either end of the headshafts. Each will handle a full range of bar sizes—on a 90,000 ton per year basis.

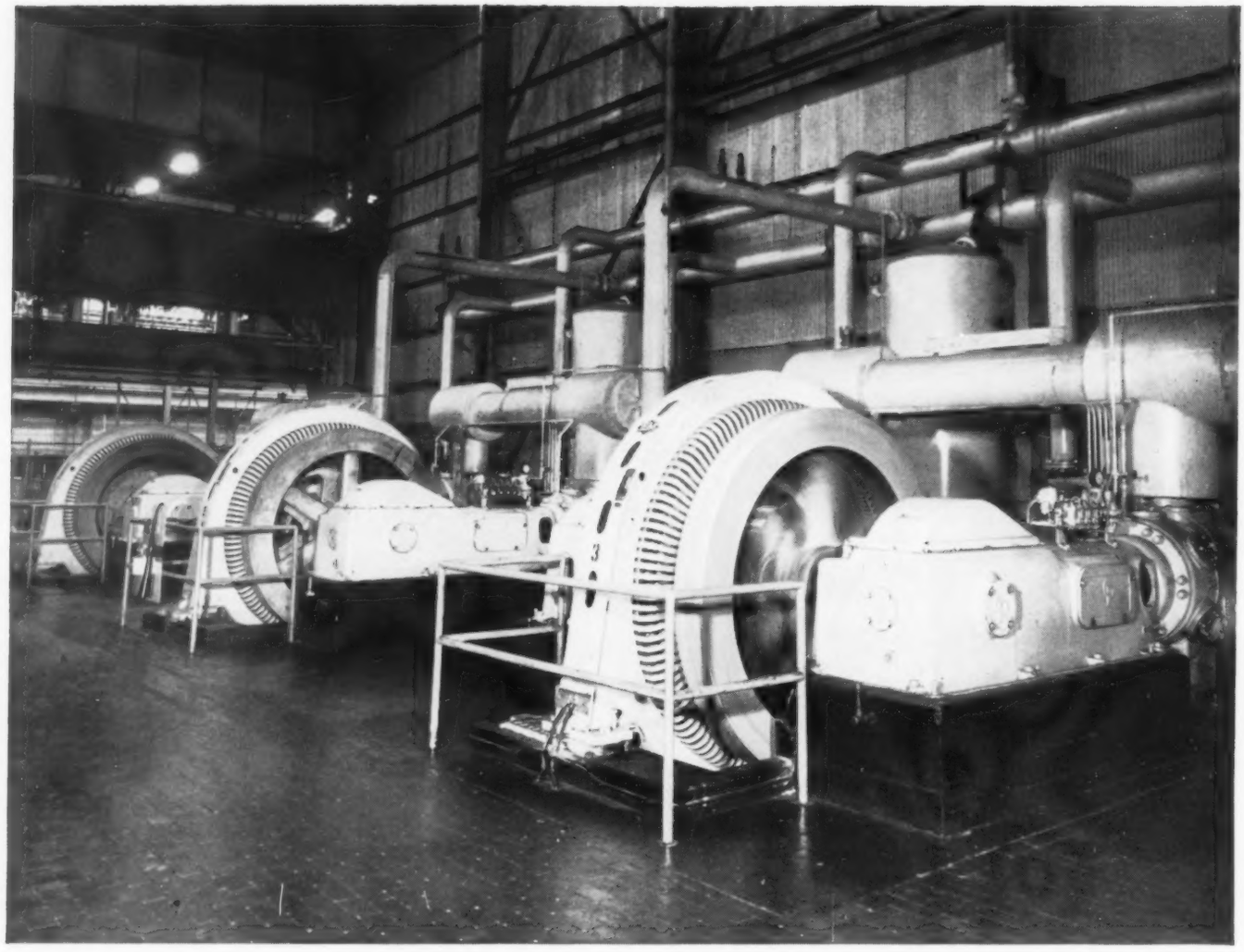
Northeast Engineers, working as a creative group, are daily solving mechanical problems to increase production and make individual operations or the total plant concept more economical. A Northeast team is available for your next improvement or plant expansion.

**Write for brochure No. 960C. Complete with photographs, diagrams and space for your specifications.**

**NORTHEAST**

**NORTHEAST OHIO MACHINE BUILDERS, INC.**

330 North Main St., Columbiana, Ohio



Above are three 500 hp, 225 rpm, 2300 volt, 0.8 power factor E-M Synchronous Motors driving air compressors in the tin finishing department at the new Fairless Works of United States Steel Corporation. Three other 500 hp and five 300 hp E-M Motors also drive air compressors, in the hot strip and slab mill, central power station, open hearth pumphouse and sulfate building of the coke works.

# Power costs held low on compressor drives at new Fairless Works

Supplying air for controls, tools, handling systems and maintenance equipment is vital business at Fairless Works. And cost of power for operation of the air compressors is an item to be watched in such a large mill.

That's exactly where the E-M Synchronous Motors fit in. They help contribute real economy and rugged reliability to compressor operation.

**First of all,** these 11 E-M Motors are capable of supplying approximately 2700 reactive kva to improve plant power factor, a significant element when you want to minimize power costs.

**Secondly,** the inherent high efficiency of E-M Synchronous Motors utilizes power most sparingly.

Other economies are accomplished by use of simple and low-cost full-voltage control for across-the-line starting. Maintenance economy is foretold by simplicity of E-M Synchronous Motor direct-connection . . . by extra strong lashing of E-M stator coils . . . by the high capacity of E-M cage windings to withstand repeated starting stresses.

To get top performance from your large compressor drives, discuss your needs with your nearest E-M sales engineer. And write factory for E-M Synchronizer No. 42, a special issue on the ABC'S of Synchronous Motors

**ELECTRIC MACHINERY MFG. COMPANY**
**MINNEAPOLIS 13, MINNESOTA**

E-M

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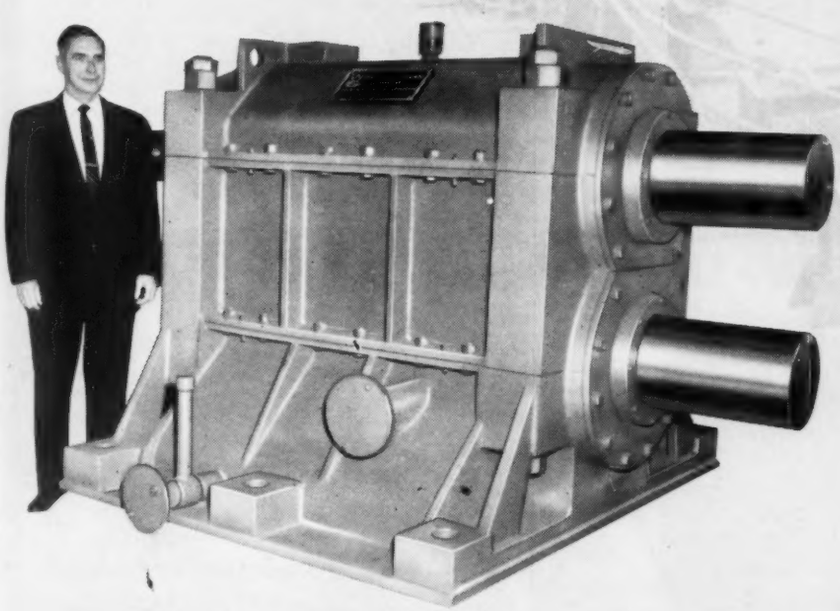
*Specialists in making motors do*
**EXACTLY WHAT YOU WANT THEM TO**

HOW WESTERN GEAR SERVES THE STEEL INDUSTRY

# A BLOOMING MILL PINION STAND WITH ANTI-FRICTION BEARINGS!

Designed and built on the West Coast, this 2-high pinion stand was completed in 10 weeks time from drawing board to customer's plant. Equally as important as speed of delivery are the distinguishing marks of Western Gear quality built into this blooming mill drive—as in all key steel industry products. Anti-friction bearings on alloy steel shafts—protected double shaft seals—through-hardened precision cut gears for smooth, silent efficiency—and integral lubrication—are exemplary features of Western quality. Housing of rugged, stress-relieved construction encasing both pinion stand and reduction gears, means substantial savings in installation costs and mill floor space.



Finished 2-high pinion stand

## *Engineering Facts*

*24" center distance—2-high pinion stand*
*1750 HP at 60 RPM*
*Reversing service for blooming mill duty*
*Shipping weight—34,000 lbs.*

Western Gear experience in the steel industry can prove invaluable to *your* special needs or mill production problems. For full information, write, wire or phone: **WESTERN GEAR CORPORATION,** Industrial Products Division, P.O. Box 126, Belmont, California—LYtel 3-7611

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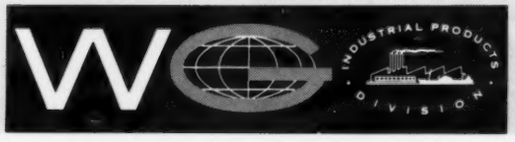
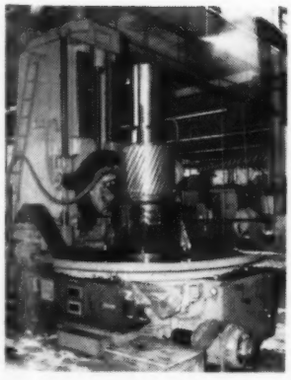
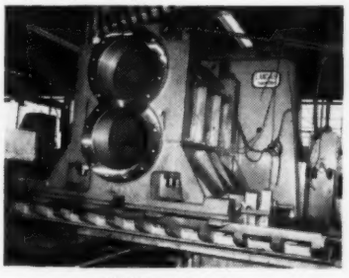


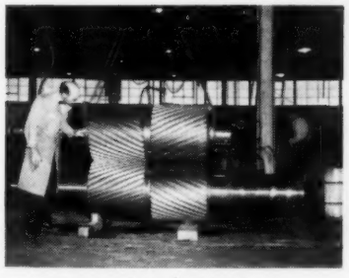



Hobbing the pinion gear

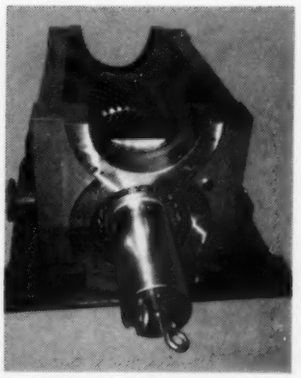


Milling the case

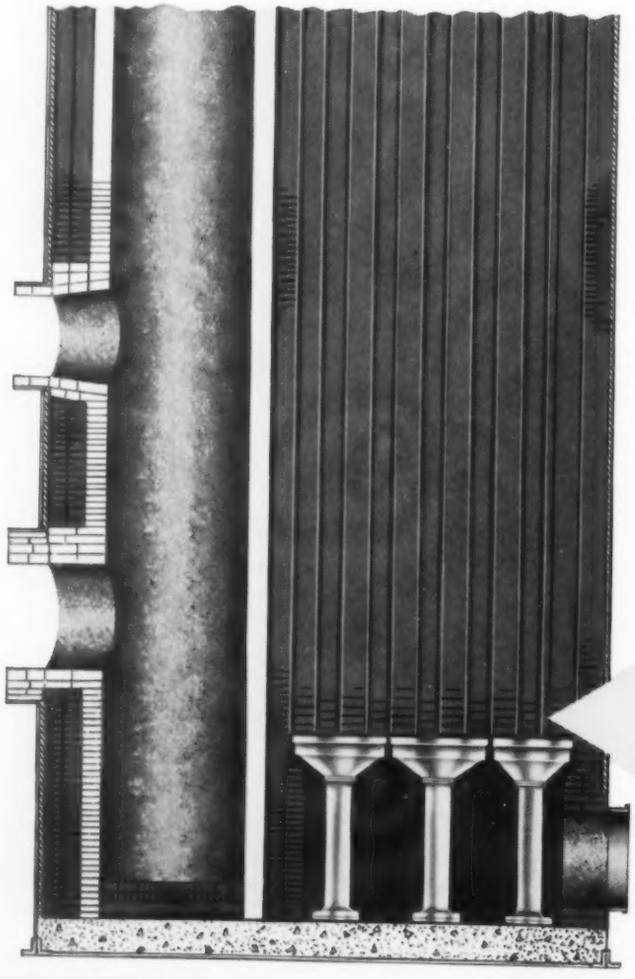
Lower case assembly view



Inspecting gear finishes



# GREFCO *has superior Refractories for high*



**SUPERAC-K Stove**

High-fired superduty Stove brick manufactured at Olive Hill, Kentucky from high purity Georgia kaolin. High refractoriness and density, plus very low porosity properties make it ideally suited for the upper section of the checker setting.

GREFCO

50th Anniversary
1911-1961

# GREFCO

GREFCO has for 50 years been a leader in the manufacture of refractories for all parts of the blast furnace stove.

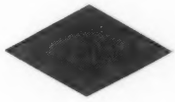
GREFCO has the manufacturing know-how and capacity to meet your requirements on brick quality, size tolerances and delivery schedules of standard sizes and special or multihole stove brick shapes.

GREFCO has met the demand for higher hot blast temperatures with new and improved refractories to withstand stove top dome temperatures up to 2400°F.

## temperature blast furnace stoves

**HI-SIL Stove**

Improved semi-silica brick manufactured at Warren, Ohio, with outstanding ability to withstand hot loads. Develops a surface glaze during service that retards the penetration of alkali laden gases. For use in the inner dome lining, combustion chamber skin wall, and upper well wall, shell or ring wall, and breast wall. Sometimes used for a part of the upper section of checkers.



**OLIVE HILL Stove**

Standard of the industry when high duty standard sizes, special or multihole checkers are indicated. Manufactured at Olive Hill and Hitchens, Ky. For use as outer dome lining, lower well walls, shell or ring walls, breast walls and checkers.

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SYNTRON MECHANICAL VIBRATING CONVEYORS

## SAVE BULK MATERIALS HANDLING COSTS

Many industries through the nation are recording big monthly savings in operating and maintenance costs by using Syntron Mechanical Vibrating Conveyors.

Designed to handle most bulk materials efficiently at high ton per hour rates—sand, sinter, castings, hot or cold—constructed to withstand the wear and abuse of foundry operation, built for long dependable service with a minimum of maintenance.

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*Conveying hot castings in a modern foundry.*

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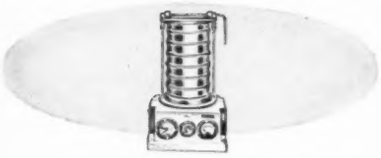
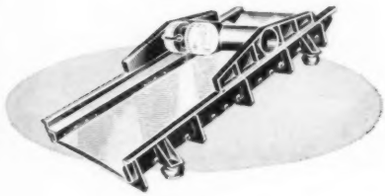
*Other SYNTRON equipment of proven dependable quality*

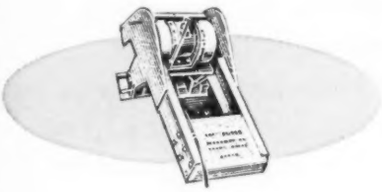


*Test Sieve Shakers*



*Vibrating Screens*

*Roll Neck Seals*



*Car Shakers*

*Lapping Machines*

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**699 Lexington Avenue • Homer City, Pa.**

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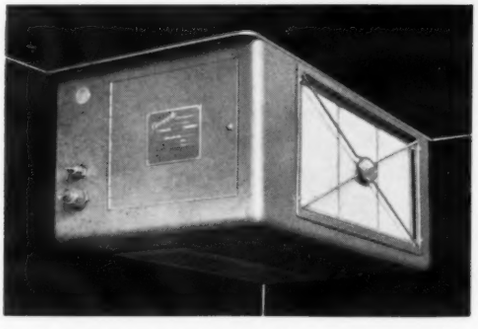
**It ❶ cools, ❷ dehumidifies, ❸ removes dust, ❹ absorbs fumes and gases, ❺ heats**

Patent Pending



Split and Self-contained systems, Water-cooled and Air-cooled, with conditioners for any location, add up to the most diversified line of heavy duty air conditioning offered today. From top to bottom: floor conditioner; seat-type conditioner; ceiling conditioner. In addition, Wall and Exterior-mounted conditioners complete another ***"5"***, making Correct-Air the only builder with 5 basic installation styles.

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Raise human efficiency in hot spots to the level of your mechanical progress. Give your men clean, healthful air summer and winter. Watch the improvement in operator alertness and safety; enjoy better industrial relations. You'll be repaid many times over.

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# Introducing the PLUS + POSITIVE

An improvement in Centralized Lubrication—

far better than anything offered before

- PRECISE METERING OF LUBRICANT—from drops to .300 cu. in.
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- BUILT-IN CHECK VALVES—assures positive error-proof operation.
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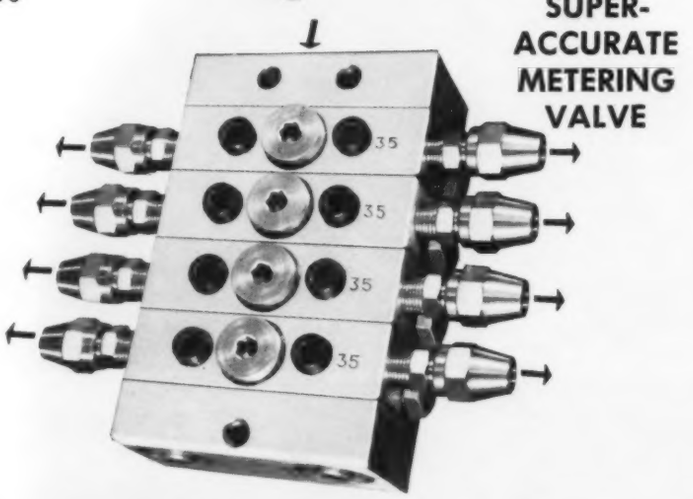
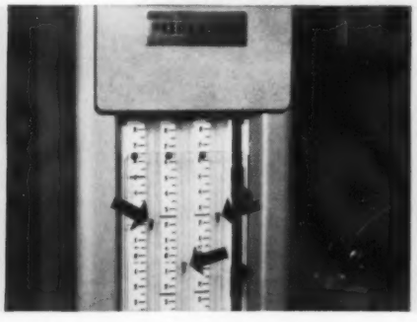
- NEW 3-LOBED PISTON DOUBLES SEALING AREA.

**Write for more information on Trabon's new Broken Line Indicator—the all-hydraulic (non-electric) central-signalling warning device.*





**Precision machining + Micro-accurate gauging = "Plus Positive" Metering**

Individual "Match-honing" of Cylinders to fit each 3-lobed piston provides superior sealing—accurate metering.

Super-precision air gauges maintain match-honed piston-cylinder fits to tenths of thousandths of an inch.

All bearings receive exact force-fed amounts of lubricant. No skipping or under or over lubrication for *any* bearing.

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# Equipment News...

## ROBOT UNIT

△ A robot which may herald a sort of second Industrial Revolution in which machines relieve men of much of the drudgery of factory work was demonstrated recently by Consolidated Controls Corp., a subsidiary of Consolidated Diesel Electric Corp.

Designed to speed factory production and to cut costs by taking over repetitive routines now performed by men, "Unimate," as the device is known, has an arm which duplicates the functions of the human arm and a "brain" which can remember 200 sequential commands and direct the arm to act in accordance with the stored information.

The device "learns" to perform a task by simply being led through the motions once. Thereafter, it can repeat the operation continuously until a new routine is taught to it.

A variety of hands or hand tools designed for particular chores can be fitted on the arm—clamps to pick up objects and move them from one place to another; pneumatic wrenches and screwdrivers and paint spray guns, for example.

In a demonstration of how a robot might be used to operate a machine tool, in this instance a forging press, "Unimate" removed a metal billet from a conveyor chute, carefully placed it on a die in the press and then actuated the press. After the press had closed and opened, "Unimate" picked up the billet, turned it over and placed it on a second-stage die. It then picked up a new billet and put it on the first die. After actuating the press again, the robot removed the finished piece from the second die and dropped it in a box. The routine continued automatically.

"Unimate" bears little physical resemblance to a human being; it looks more like a miniature gun turret on a fighting ship. A box-like base contains all of the control and operating mechanisms; there are no separately mounted peripheral devices. From the pedestal a central column rises. From the top of the column "Unimate's" arm extends.

Hydraulically operated, the arm can telescope in length from 3 ft to 7 ft; in a horizontal plane it can sweep an arc of 220 deg; in a vertical plane, 60 deg. With its arm fully extended it can reach from within 4 in. of the floor to 90 in. above the floor. All told, it can grasp objects within a swept volume of 350 cu ft.

At the end of the arm is a "wrist" which, like a human wrist, can both bend and rotate. The wrist joint is terminated in a hand designed to grasp a particular object. Usually, this hand bears some resemblance to a lobster claw. Since the hand is pneumatically operated, the pressure with which it grasps an object can be controlled by varying the air pressure supplied. Thus, "Unimate" can handle fragile objects gently as well as grasp heavy objects firmly.

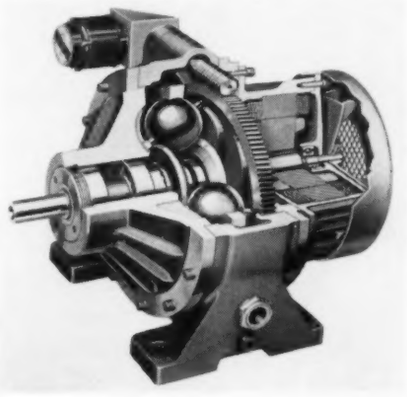
The "brain" is a patented magnetic memory drum, "Dynastat," which, unlike previously developed drums, can be "read" while standing still. Its surface consists of segments of magnetic material which can be either magnetized or demagnetized in a pattern conforming to instructions recorded when the arm is being led through a task for the first time. Since the drum does not have to rotate to present its readings, it simply steps from one position to the next and waits for a signal that the arm has assumed a corresponding position before stepping on to present the next set of positioning instructions.

In addition to controlling the arm and hand, the memory drum also can control external devices. For example, in feeding a punch press it can actuate the press after the work piece has been placed on the press by "Unimate" and the hand has withdrawn a safe distance.

Entirely self-contained, the unit will be sold on a ready-to-operate basis. The owner simply moves it into position with a fork lift truck, plugs it in, teaches it its first chore and walks away. When he wants it to operate another machine or to handle material in another portion of his factory, he simply moves it by means of a fork lift to a new location.

## MOTOR-DRIVE UNIT

△ Exceptional compactness has resulted by incorporating a motor with a mechanical variable speed drive, manufactured by the Cleveland Worm & Gear Div., Eaton Manufacturing Co. Utilizing an integral "pancake" style motor, the new Motorized Speed Variator



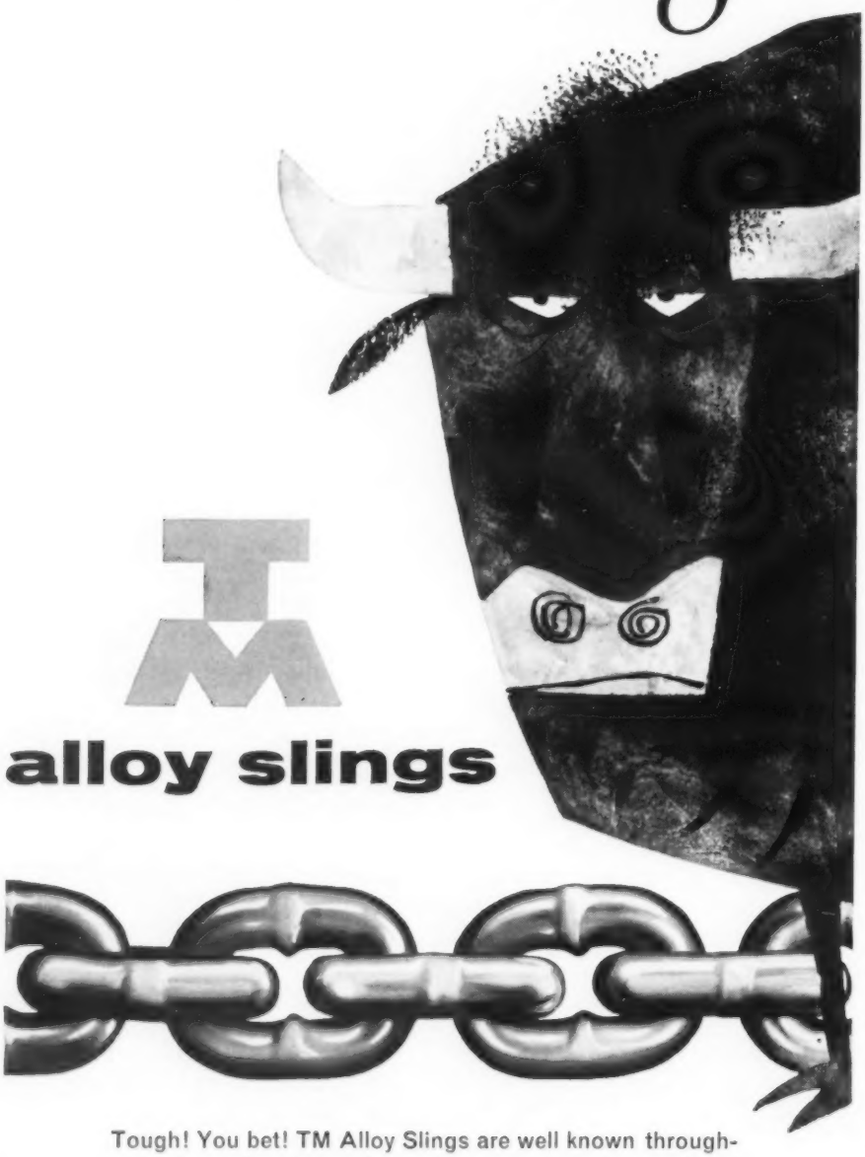
requires only slightly more space than an equally rated conventional motor. The new line is available in sizes from ⅓ to 15 hp. Motors are a-c radial air gap design and conform to NEMA design "B" specifications.

Unique design insures precise speed setting and repeatability. It provides variable output speeds with 9:1 and 6:1 ranges. Since it employs the rolling action of a series of balls, it permits smooth adjustment of the output speed while operating under load.

Power is transmitted through input shaft to a beveled drive disk in contact with axle-mounted alloy steel drive balls. Input shaft rotation causes balls to rotate about their axles, which in turn transmits power to the output shaft by a similar ball-disk contact. Output speed is determined by relative

VALUED FOR

*Brute Strength*



TM alloy slings

Tough! You bet! TM Alloy Slings are well known throughout industry for plenty of muscle, low overall costs and that extra measure of safety. Taylor's safe, sure-grip Tayco Hooks and up-to-the-minute, *scientific*, quality control contribute to the brute strength of TM Alloy Slings. Factory-made to your specifications. Available nationally through industrial distributors, steel warehouses and hardware wholesalers. Write for Bulletin 14A.

Taylor Made CHAIN SINCE 1873

Prompt repairs on alloy slings in both plants.

S. G. TAYLOR CHAIN CO., Inc.
Plants: Hammond, Indiana
3505 Smallman St., Pittsburgh, Pa.

lengths of the contact paths on input and output sides of the balls. By tilting both axles and balls, relative lengths of the two contact paths are varied to give increasing or decreasing ratios.

## REPEATERS

△ Escapement and breakout features are combined in four repeaters designed by Birdsboro Corp. for Pacific States Steel Corp. The repeaters, now under construction, are to be installed on a 10-in. mill for rolling merchant bars, structurals, rods and skelp.

Incorporating both escapement and breakout repeaters on each of the four units, (1) eliminates the need for interchanging repeaters when rolling rod and merchant sections, (2) enables the mill to roll a wide range of products on the same set of repeaters and (3) saves the time and expense of interchange necessary with equipment of conventional design.

The escapement type repeaters are designed to work with merchant sections that are single stranded. The breakout repeater in each combination unit is to be used in producing multiple stranding of rods. To save costly downtime, each unit will be equipped with four breakout troughs for rod and one escapement device for merchant bars.

When a rolled section is too heavy to handle on the escapement repeater, the repeaters will be shifted, not removed, into proper position. The runout trough will be brought in on the side of the repeaters in line with the mill and runout tables. This movement automatically positions a bar turner, incorporated as part of the repeaters, in line with the next stand the stock is to enter. Thus bars can be turned, where required, by pass design.

Along with the repeaters, Birdsboro is building two cooling bed parting shears that will be fly wheel driven and actuated by an air clutch and air brake. Each shear will cut shapes up to 3 sq in. at speeds ranging from 900 to 2200 fpm.

Also being built are two crop shears, fly wheel driven with an air clutch and air brake. They are designed to cut the crop ends of bars and merchant sections at speeds of 450 to 900 fpm. One shear

## North American recommends:

# SAVE by being SAFE

### Reduce fire loss & insurance costs

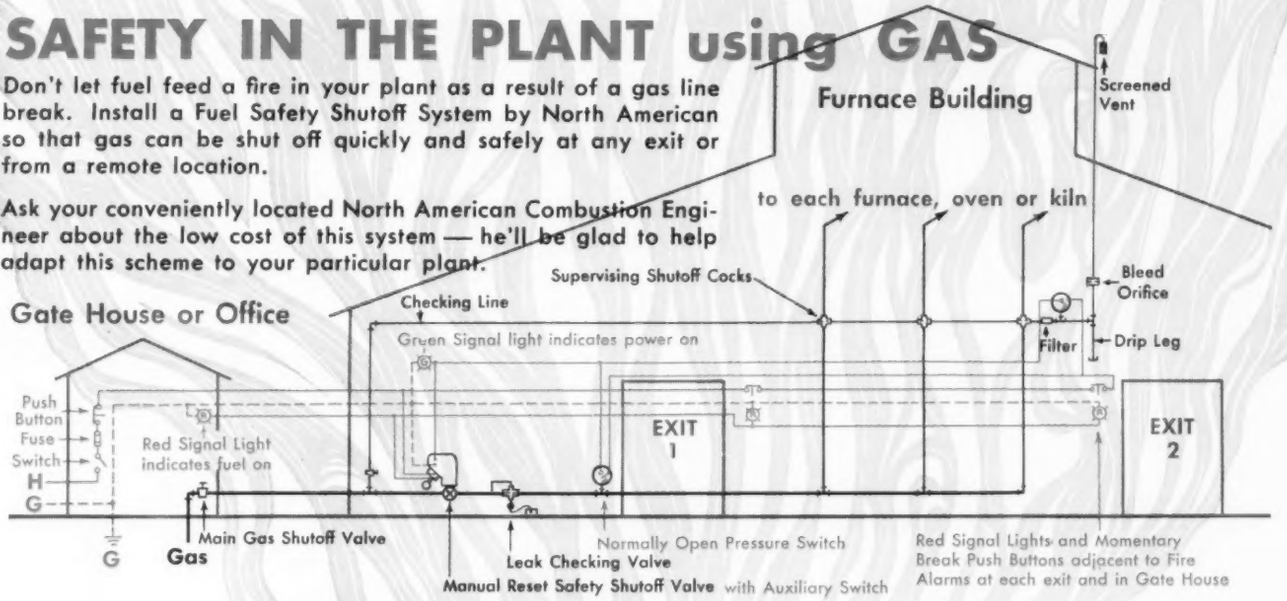
In industrial fires, severe damage results from failure to shut off fuel supply lines **immediately.** This gives the fire a "shot in the arm" before fire-fighting equipment can be put to use.

To assure quick fuel cut-off, combine North American Safety Shutoff Valves and Supervising Cocks in a **Safe Supply System** for all fuel lines coming into your plant. . . . . **Here's How:**

## SAFETY IN THE PLANT using GAS

Don't let fuel feed a fire in your plant as a result of a gas line break. Install a Fuel Safety Shutoff System by North American so that gas can be shut off quickly and safely at any exit or from a remote location.

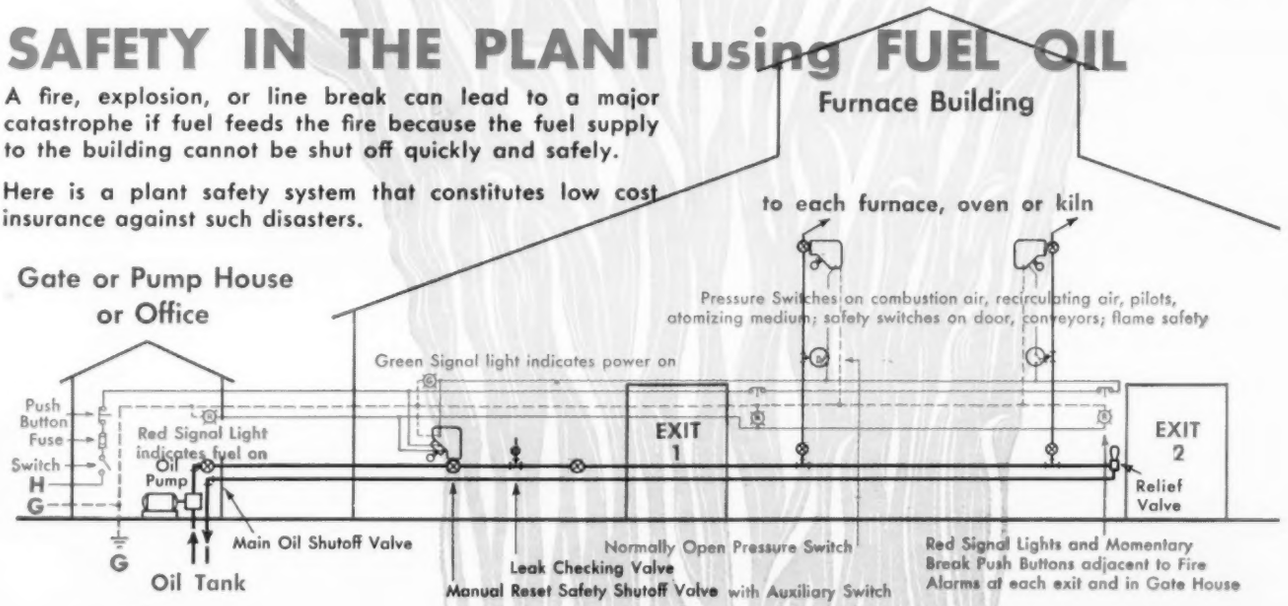
Ask your conveniently located North American Combustion Engineer about the low cost of this system — he'll be glad to help adapt this scheme to your particular plant.




## SAFETY IN THE PLANT using FUEL OIL

A fire, explosion, or line break can lead to a major catastrophe if fuel feeds the fire because the fuel supply to the building cannot be shut off quickly and safely.

Here is a plant safety system that constitutes low cost insurance against such disasters.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Pressure Switches on combustion air, recirculating air, pilots, atomizing medium; safety switches on door, conveyors; flame safety
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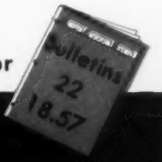
Push Button
Fuse
Switch
H
G
Red Signal Light indicates fuel on
Oil Pump
EXIT 1
EXIT 2
Relief Valve
Main Oil Shutoff Valve
Oil Tank
Normally Open Pressure Switch
Leak Checking Valve
Manual Reset Safety Shutoff Valve with Auxiliary Switch
Red Signal Lights and Momentary Break Push Buttons adjacent to Fire Alarms at each exit and in Gate House

For engineering information call your nearby North American office or write for




NORTH AMERICAN for COMBUSTION and Hydraulic Controls

**The North American Mfg. Co.**
**Cleveland 5, Ohio**

is to crop 20-in. wide flats, while the other will crop shapes up to 2 sq in.

## PROXIMITY LIMIT SWITCH

△ A new proximity limit switch designed to detect any metal object without physical contact has been developed by General Electric Co.'s General Purpose Control Department.

The switch will sense nonferrous materials up to one half in. and ferrous material up to an in. away, according to department engineers.

All-transistorized circuitry (no vacuum tubes) is self-contained in the operating head of the CR115 D switch, contributing to its high reliability, the engineers explained.

Encapsulation protects all internal components of the proximity switch from coolants or contaminants—the sensing head will even operate under water.

The device is rated at 30 volts, d-c, input; 30 volts, d-c, 250 milliamperes, output. Its maximum repetitive accuracy is 0.005 in.; maximum differential is 0.01 in.; and operating time is 20 milliseconds. It will operate in ambients up to 150 F.

The proximity switch may be used with static control or magnetic devices.

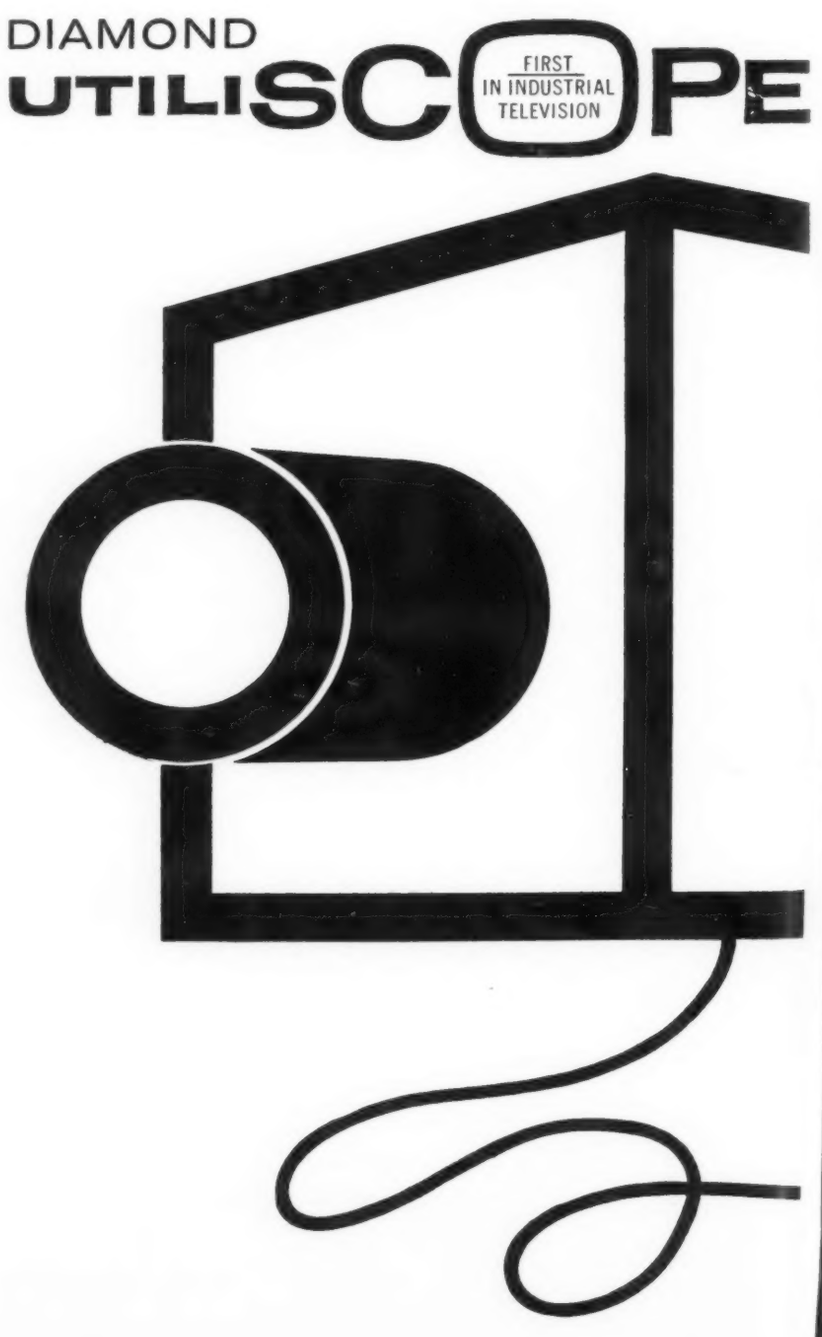
## CHROMIUM PLATING

△ An important factor in the operation of the new electrolytic tinning line at Granite City Steel Co. lies in the use of "Crodon," the chrome plate by Chromium Corp. of America. As a result of experience over the past 15 years, with plated rolls in their original alkaline electrolytic tinning line, Granite City specified "Crodon" plating finish No. 3 on the conductor rolls for the new electrolytic line.

The use of chromium plating on conductor rolls for electrolytic tinning lines is quite universal, including both acid type and alkaline type lines. There are two attributes to electrodeposited chromium that make it desirable for this type of operation: the extreme hardness of chromium to resist wear, and its ability to resist pickup of metal. The special finishes developed for this type of surface also play an important part in the operation of the plated rolls. Chromium is highly resistant to corrosion—another reason for its use in conductor rolls in electrolytic lines. As a result of these factors chromium plating makes it possible to maintain the conductor rolls in service for much longer periods of time, and produce more tin plate, with less trouble and lower maintenance costs.

In addition to the conductor rolls, the looper tower rolls are also "Crodon" plated. Here again, a special finish, with just the right amount of grain in sufficient smoothness to avoid marking the sheet, has been highly successful. It is the same ability to resist pickup that makes the plating of both the entry and exit of the tower looper rolls highly desirable. The same procedure is used on all rolls throughout the electrolytic tinning line.

To illustrate the durability of plated roll surfaces under the operating conditions of an alkaline type electrolytic tinning line, the current carrying rolls in the original Granite City line have an average life expectancy of eighteen months before resurfacing is necessary. The tower looper rolls in the original Granite City line have served continuously

up to ten years before the "Crodon" surfaces require reconditioning.

## TUBE AND BAR FEEDERS

△ Two new drive units specially built to feed round tubing and bar stock are now available from Magnaflux Corp. Both units, engineered for rugged mill service, are designed primarily to work in conjunction with eddy current tests. This through-coil test equipment, also developed by Magnaflux, automatically locates defects in ferrous or nonferrous products such as rod, wire and seamless or welded tubing and pipe. Constant speed, minimum deviation from the centerline of the coil, and easy access to the coils for rapid size change-over are necessary features provided by the feeders, designated as Type X-2316 and Type 2366.

The X-2316 handles diameters in a range from $\frac{1}{4}$ to 4 in. The variable speed drive, working through V-pulleys, offers speeds from 40 to 400 fpm, controlled by a "Forward-Neutral-Reverse" switch in combination with a potentiometer. The coil platform is rigidly supported and adjusts for fine alinement between coil and test part by means of a gear and screw thread arrangement. Four powered driving rolls, either bakelite or steel, provide positive tracking through the coil. Four upper, rubber-tired hold-down rolls adjust to give spring loaded pressure to various diameters. All roll shafts are supported in ball bearings. Operation is from 110/60/1 a-c power source.

The X-2366 is smaller in size and accommodates diameters from $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. Its constant speed reduction motor, working through a V-pulley arrangement, offers 2-speed operation, either 180 or 300 fpm. Other speeds may be obtained by changing the pulley sizes. An "Off-On" switch controls the 110/60/1 a-c drive motor which can be connected to run in either direction. An adjustable platform insures alinement between coil and test part. Features of the driving rolls and hold-down rolls are similar to those on the X-2316 feeder.

Thus, positive positioning and positive speeds of feed are now available to handle rod or tubular goods automatically, and with heavy duty mill-type equipment.

## PNEUMATIC CONTROLLER

△ The Bristol Co. has announced the availability of its new Series 532 recording pneumatic controller. Good frequency response (essentially flat to over 300 cycles per minute), low air consumption (less than 0.1 scfm), high exhausting capacity (well over 3 scfm at 1 psi drop), high tolerance to shock and high temperature stability can be expected from the unit, according to the company announcement.

Key to these performance characteristics is the A/D control unit recently developed by the company. The case of this unit is made of die cast aluminum with working parts of stainless steel, Ni-Span-C feeder bellows and Neoprene diaphragms. Construction of this position-balance unit has been kept simple, making it a rugged unit that is easy to maintain.

The Series 532 is available with a choice of four modes of control and may be used with any of Bristol's standard measuring elements for the control of pressure, temperature,


LOOKS AT 5000°
FURNACE INTERIOR . . .
FROM TWO FEET AWAY!

Constant and remote visual observation of critical furnace operations is yours with Utiliscope—first in Industrial Television. Featuring a unique water/air-cooled housing, a new Utiliscope camera operates in ambients of 150°F. and higher and is capable of viewing 5000°F. furnace interiors from less than two feet away!

Surprised that closed-circuit TV stands up under such punishing conditions? You'll be even more surprised when you find out *everything* that Diamond Utiliscope is doing to help the Iron and Steel Industry cut costs by increasing production efficiency. Send us the coupon below and get complete details.

Diamond® Electronics
Division of Diamond Power Specialty Corporation

Diamond Electronics • Lancaster, Ohio
Please send complete information on how Diamond Utiliscope can help reduce operating costs and improve operations.
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Title_____
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B·I·F FIRST . . . IN MEASUREMENT AND CONTROL OF MATERIALS FLOW

Is messy carbon feeding giving you a headache? Costly housekeeping and employee health problems cutting your profits?

Whether you're feeding floodable carbon (smoke) or free flowing granular carbon, organic or mineral carbon, B-I-F's totally enclosed feeding systems provide automatic, continuous control of the flow of this hard-to-handle material . . . at high accuracy. Regardless of material characteristics or process conditions, B-I-F has the performance-proved, engineered system for more efficient carbon feeding.

**Free Facts**

Continuous feeding/blending saves material, reduces costs, controls quality . . . results in bigger processing profits. Write for the Facts today!

B·I·F Industries

BUILDERS-PROVIDENCE • PROPORTIONEERS • OMEGA
547 HARRIS AVENUE, PROVIDENCE 1, RHODE ISLAND

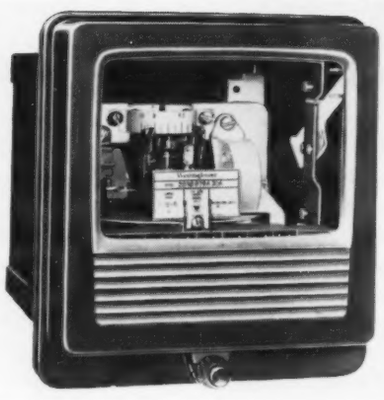
flow, humidity or differential liquid level. The proportional controller is easily adjustable, even in the low proportional band region, from 0 to 400 per cent, direct or reverse acting, by simply turning a dial. The proportional-plus reset model is adjustable from 0.1 to 100 repeats per minute, with the same 0 to 400 per cent proportional band adjustment.

The proportional-plus-derivative model offers the same proportional band adjustment, plus an adjustment on derivative time from 0 to 10 minutes. The fourth model available is a differential gap controller with an adjustment from 2 to 100 per cent of scale.

The instrument case is a compact $14\frac{3}{4}$ in. x $10\frac{3}{4}$ in., made of die cast aluminum, with a fully gasketed weather resistant door. Recording is on an eight-in. round chart. All standard chart rotations from eight-hour to seven-day are available.

## CURRENT-SENSING RELAY

△ A new current-sensing relay (Type COD) with independently



adjustable high- and low-current stationary contacts for switching and control operations is offered by the Westinghouse Electric Corp.

The relay is available with either a tapped or a nontapped electromagnet. The tapped COD relay is supplied in the following ranges: 0.5 to 2.5, 2 to 6 and 4 to 12 amp a-c. The scale on this relay is marked in per cent of tap value with a range of 80 to 110 per cent. The nontapped unit is available with a range of 0.5 to 2.0, or 1.5 to 6 amp a-c. The scale of the nontapped relay is marked directly in amp.

(*Please turn to page 231*)

**WHEN YOU NEED HELP IN A HURRY—**

Koppers coupling service cuts costly down-time

**Not every coupling service need is an emergency. But it's the emergencies that really test a good organization. That's why Koppers maintains experienced field engineers and outstanding stock facilities throughout the country. In addition, if it's a Fast's Coupling you're replacing, we have a serial number and specific application history for every Fast's for easy reordering. And our modern manufacturing facilities have the extra capacity to lick an emergency for special requirements.**

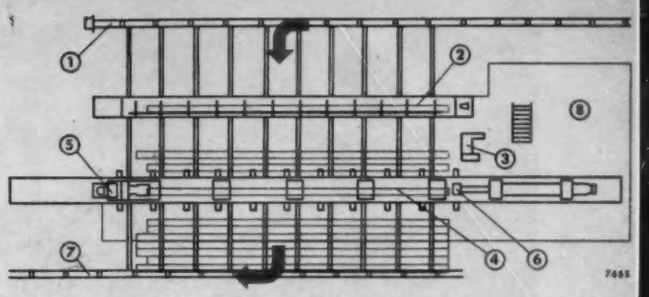
***Example:*** **A modern windowless bank in Georgia was able to open for business as usual only because Koppers flew in a completed replacement coupling for its air conditioning unit. Elapsed time . . . request phoned to Baltimore after 10 in the evening . . . coupling arrived before 7:30 next morning.**

**KOPPERS COMPANY, INC., 104 Scott St., Baltimore 3, Md.**

KOPPERS **FAST'S COUPLINGS**
Engineered Products Sold with Service

P 5/123 a

**SCHLOEMANN**
ROLLING MILLS · HAMMERS · PRESSES




① Approach roller table ② Tube washer ③ Main control desk ④ Tube tester ⑤ Traversible test head with control desk ⑥ Fixed compensating test head ⑦ Run-out roller table ⑧ Pit for pumps and controls

## Hydraulic tube testing equipment with automatic controls

In addition to production equipment for the manufacture of rolled, extruded and welded tubing, SCHLOEMANN has included Tube Testers in its production program for a long time. Details of a new automatically controlled unit for testing tubes up to 16½ in. in diameter and 59 ft. long are as follows:

### Features and advantages

- The design and arrangement of the entire plant and the automatic sequencing – from the loading to discharging of the tube – assure a high output, even when handling tubes of maximum diameter and length.

- The automatic tube washer, arranged in front of the tester, flushes out of the tube all foreign matter, such as mill scale, swarf and weld nuggets. The tube is rotated in a tilted position while the water spray is in action resulting in positive and thorough cleaning.

- A turning device permits welded tubes to be rotated prior to testing, so that the operator has full vision of the weld seam.

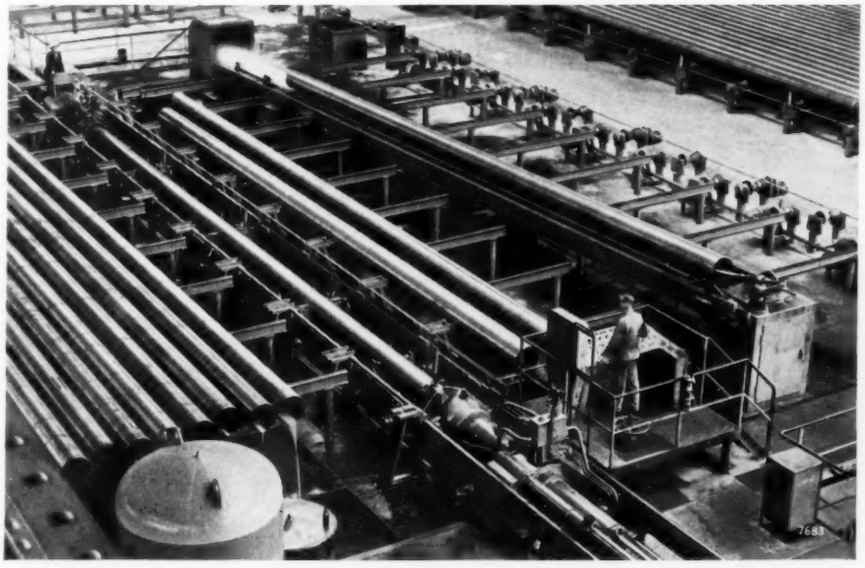
- The tube loading, discharging, and clamping devices are independently operated units. This increases operational dependability and simplifies servicing and maintenance.

- The compensating tester-head prevents small-size tubes from buckling before clamping and accommodates all variations in the length of material due to stress without impairing the seal.

- After the tube has been tested, a pull-back device removes it from the fixed tester head, so that it is ready for discharging.

### Technical data

| | |
|---|---|
| Tube size o.d. | min. 6⅝ in. |
| | max. 16½ in. |
| Tube length | min. 20 ft. |
| | max. 59 ft. |
| Testing pressure | 1,420 to 3,550 p.s.i. |
| Clamping power | 182 U.S. tons |
| Capacity per hour | 70 to 110 tubes |

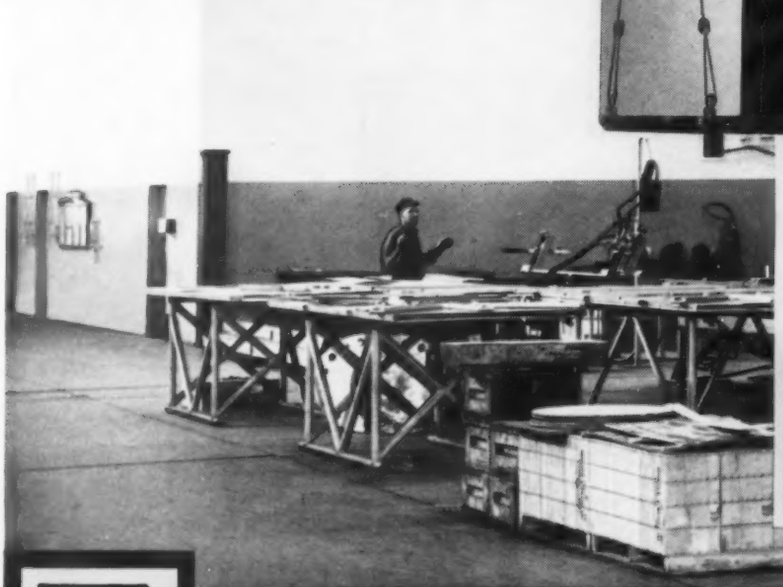


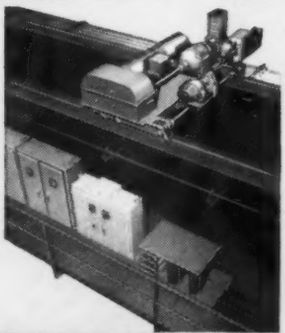
From the approach roller table the tubes are transferred to the washer; after all foreign matter is removed, the tubes are tested in the press in an automatic sequence. Two men operate the entire plant.

**FELLER ENGINEERING COMPANY** 1161 Empire Building, Pittsburgh 22, Pa.

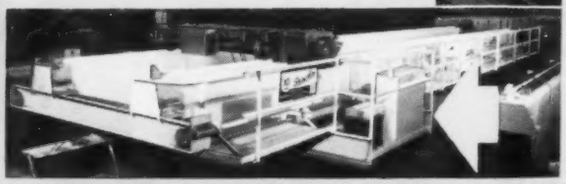
# You can

40-ton crane in midwestern heavy-metal processing plant, recently equipped with EC&M STATA Hoist Control





10-ton cranes on erection floors of Whiting Corporation *(right)* and Shaw-Box *(below)* with EC&M STATA Hoist Controllers, mounted and wired



SQUARE D COMPANY

EC&M DIVISION • CLEVELAND 28, OHIO

# spot 40 TONS—

## —OR CRACK A WALNUT—WITH

# EC&M STATA CONTROL

Now it can be done with precision by AC! EC&M STATA Hoist Control gives the finest electrically controlled speed regulation ever attained. Regardless of crane load, the operator can release the brake and hold any load stationary—a big advantage when landing loads, hooking-on, or unhooking. Also, the operator has infinite operating speeds between standstill and full load motor speed for both hoisting and lowering. The EC&M STATA Hoist Control provides these important benefits:

**Fast response** lets an operator change directions quickly, permits the hook to respond rapidly to master switch movements

**No mechanical or electrical load brakes** to mount or maintain

**Fewer trolley (collector) bars** than with any other stepless system

**Fail-safe feedback circuitry** removes power and sets brake if an open circuit occurs

**Overhoisting protection** with standard power-type (Youngstown) limit stop—no additional equipment to lower down after limit switch trips

**Simplified maintenance**—the static components, enclosed in sub-assemblies, are more reliable, more easily understood and provide convenient inspection or test points

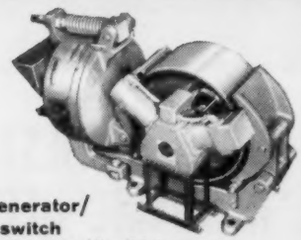
**Float control**, actuated by a push button in the master switch handle, permits standstill with the brake released; also provides creeping speeds, up or down

**Front-connected control panels** facilitate mounting, permit rapid testing or inspection. Full motor protection built into each panel

When buying cranes or revamping existing installations, investigate EC&M STATA Control

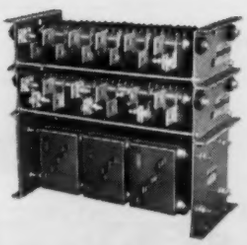
*Write* ***FOR COMPLETE FACTS*** *• Ask for Bulletin 6401—Square D Company, EC&M Division, 4500 Lee Road, Cleveland 28, Ohio*

**Compact, Coordinated Units for Easy Mounting on Crane Trolleys**



**Tach-generator/ Speed-switch** unitized for easy (flexible) connection to wheel of EC&M WB hoist brake

**Power-type (EC&M Youngstown) Safety Limit Stop** operates in normal manner to prevent overhoisting. Disconnects power, sets brake—resets automatically when master switch is moved to lower



**Resistor-reactor assembly** connects to motor slip rings... its fixed values eliminate secondary trolley collectors

*wherever electricity is distributed and controlled*

5350

# Roll Turning Lathes

## FOR YOUR HEAVIEST METAL REMOVING NEEDS

**Waldrich, Siegen, heavy roll lathe with 63" swing and 250 H.P. for highest metal removal capacity, working continuously for five years with outstanding results at The Ohio Steel Foundry Co., Lima, Ohio.**

**AMERICAN WALDRICH MFG. CORP.**
**1232 Penn Avenue, Pittsburgh 22, Pa.** • **H. A. WALDRICH G.M.B.H. SIEGEN, GERMANY**

(*Continued from page 226*)

The minimum setting between high- and low-current contacts of the relay is three per cent of tap-value current for the COD relay with taps, and 0.1 amp a-c for the COD relay without taps.

At tap-value current when using the minimum tap setting, the burden of the tapped COD relay is 2.38 va. The nontapped unit has a burden of 0.48 va at the minimum current setting, and 7.6 va at the maximum setting.

The moving contact of the relay assumes a position corresponding to the current applied to the relay and will remain in that position until the current changes to some other value. Since the relay has inverse timing, the greater the change in current, the faster the moving contact will travel.

## PRECIPITATOR

Δ An electrostatic precipitator which features high collection efficiency for any dust collection application is available from American-Standard Industrial Division. The new units are custom built to suit the job, utilizing modular construction techniques to the fullest extent. Because the unit features greater in-plant pre-assembly, field erection operations are minimal.

High efficiency is achieved in the new electrostatic precipitator through use of a unique flat collector plate design. The plate contains "pockets" which trap and hold the dust, reducing the chance of re-entrainment. Nonwelded, roll-formed plate construction minimizes the possibility of warping and produces optimum flatness, which contributes to higher efficiency. The high efficiency of the design allows its effective application under more difficult conditions where resistivity is high.

The flat plate design provides the following advantages:

1. The clean plate sparking voltage is improved.
2. The migration velocity of dust particles to the collecting electrode (collector plate) is increased.
3. Better performance is achieved with high resistivity dust.
4. There is less turbulence; the plate pockets provide an ef-

WHIRLEX fans and dust collection equipment offer the maximum in efficiency regardless of the size or operating conditions. A wide variety of designs, metals and linings are available to you from WHIRLEX!

FLY ASH ARRESTOR CORPORATION
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Bag Collectors ■ Mechanical Collectors ■ Wet Collectors
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**STANDARDIZE ON THE "PAIR FOR WEAR"**
**for hardfacing and manganese welding**

There's no need to "buy the catalog" when the "Pair for Wear" can handle 90% of your build-up and hardfacing work. Use the "Pair for Wear" wherever you need high impact and abrasion resistance. *Standardize* on them.

But *test* them first, and see how the "Pair for Wear" get their reputation for handling ease, usability, fast deposit and good-looking bead. See if the "Pair for Wear" doesn't give you *the best results you've ever had.* Write us now for technical bulletin and test samples of rods.

Available in 50 lb. standard manual packages and 50 lb. semi-automatic coils.

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AMSCO

American Manganese Steel Division • Chicago Heights, Ill.

"Buy Through Your Local Welding Supply Distributor"

Other plants in: Denver • Los Angeles • New Castle, Delaware • Oakland, California • St. Louis

Welding products distributed in Canada by Canadian Liquid Air Co., Ltd.

fective shielded entrainment area.

5. The mechanical structural features of the roll-formed plate are superior to expanded metal construction.
6. Rapping, which can be pneumatic or electric, is easier.

The unit as a whole is of all-welded construction. Structural frames, side casings, end panels and hoppers are made from heavy gage steel plate.

A choice of four types of high voltage rectifier is available: silicon, selenium, high voltage vacuum tube (Kenotron) or mechanical.

The control can be either a saturable reactor, a monocyclic network or a resistor type.

## BASIC BRICK

△ The availability of a new hydration resistant basic refractory brick for use in the subhearth areas of open hearth and electric steel furnaces has been announced by Kaiser Refractories & Chemicals Div., Kaiser Aluminum & Chemical Corp.

The new brick called Kaiser Hi-Mag is 95 per cent magnesia and was developed to replace PDS brick formerly available for this purpose. The new brick is extremely resistant to hydration and retains the principal features of PDS brick consisting of high MgO, high density and high refractoriness. In addition, the brick is low in chromic oxide and iron oxide. These two compounds, if present in substantial amounts, tend to destroy high magnesia brick in subhearth areas because of their reaction to alternating oxidizing and reducing atmosphere.

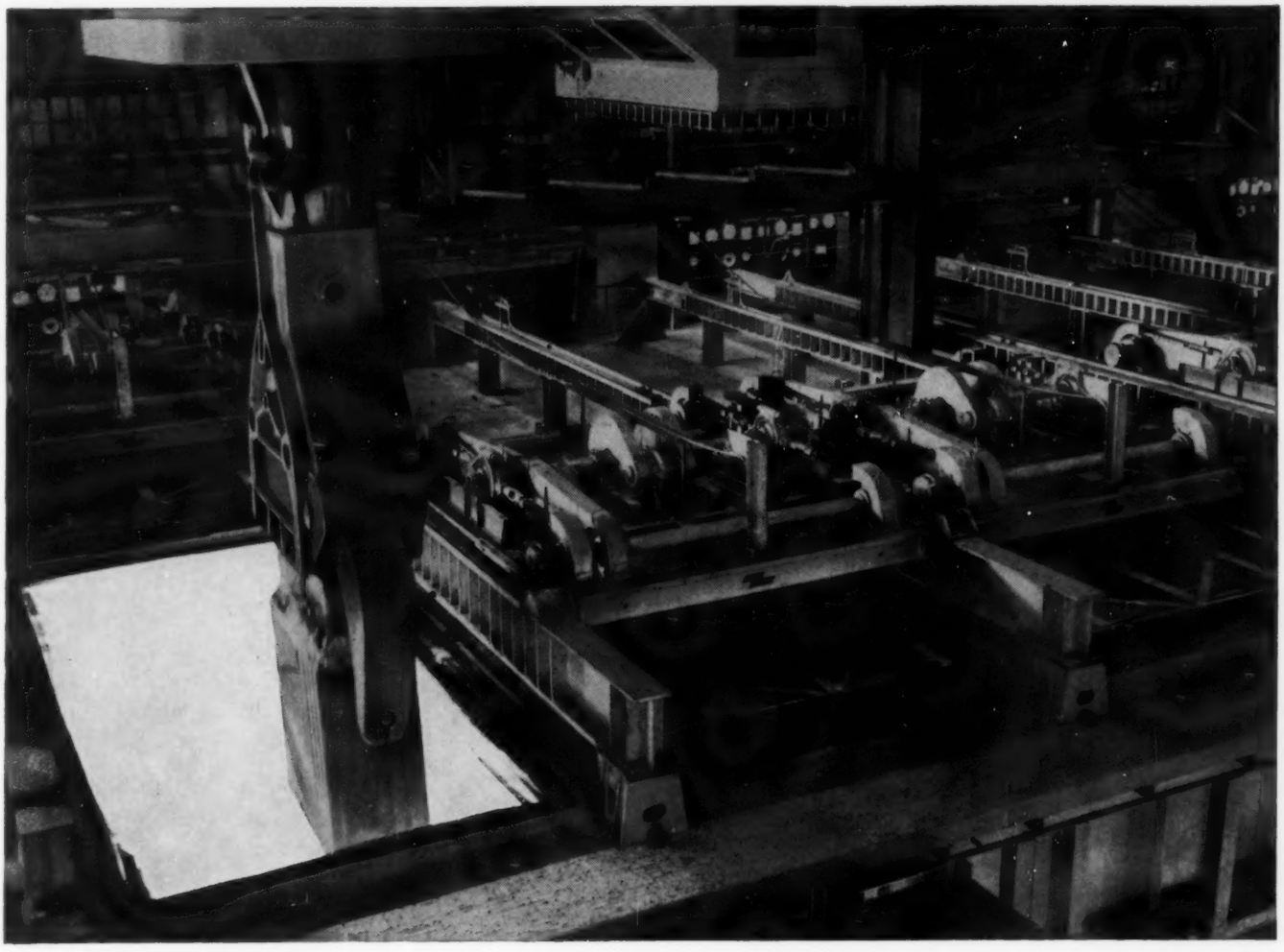
The resistant to hydration minimizes damage to the brick caused by moisture from newly-rammed bottoms, condensation of water when furnaces are cooled or water accumulation from leaks in water-cooled positions in the furnace.

In laboratory tests, Kaiser Hi-Mag brick was unaffected after 15 hr in an autoclave saturated with a 100 per cent steam atmosphere and at a pressure of 80 psi.

The refractoriness of the brick tested to 2822 F using the standard ASTM hot load test. Porosity of the brick amounts to 20.5 per cent.

## ROTARY SPOT PRINTER

△ Jas. H. Matthews & Co. an-



## As more and more steel companies expand they specify SALEM Soaking Pits

When steel companies require new soaking pits to heat ingots for rolling, more and more they are specifying Salem. One steel company operating official recently said, "The previous installation heated more steel ingots ready for rolling with less fuel consumption, less maintenance cost and better temperature uniformity than any other type of pit in our plant, so we have again turned to Salem-Brosius." The recently completed pits shown above are good examples of Salem-Brosius' advanced design. They are of the 2-burner, single-end top-fired type, fitted with needle-type metallic recuperators and *capable of placing 200 tons of steel under cover per pit.*

Good performance reports are typical . . . not only concerning soaking pits, but all other Salem-Brosius heating and heat-treating furnaces. Salem-Brosius engineers are well known for their ability to design furnaces for maximum uniform output at minimum operating cost. If your plans call for replacing old furnaces or adding new ones, why not ask us to bid? There will be no obligation.

# Salem-Brosius, Inc.

**PITTSBURGH, PENNSYLVANIA**

Salem-Brosius (Canada) Limited, Rexdale, Ontario • Salem-Brosius (England) Limited, London and Milford, England
Salem-Brosius (France) S.A., Paris, France • Salem-Brosius (Luxembourg) S.A. • General Ionics Corp., Pittsburgh, Pa.

# LOWEST COST INSURANCE

## (ONLY 3/10¢ PER BRICK!)

- Assume the cost of firebrick to be about $175.00 per thousand.*
- Figure about 350 pounds of bonding mortar per 1000 brick.
- Difference in cost between 2nd best mortar and *SUPER #3000, the "NO EQUAL" mortar,* is about $17.00 per ton, or *3/10¢ per brick!*
- **Only *3/10¢ per brick* for maximum insurance against expensive joint failure and resultant down-time.***
- **Only *3/10¢ per brick* for maximum insurance against high maintenance labor and brick replacement outlay.***

**Using SUPER #3000 costs *far less in the long run—far less* considering the labor and material replacement necessary when ordinary mortars fail.**

**SUPER #3000, the "NO EQUAL" mortar, is the lowest cost insurance you can buy. WRITE FOR SUPER #3000 SERVICE REPORTS, TECHNICAL DATA, FREE SAMPLE.**

*

*Cost of SUPER 3000 "insurance" is only 1/60 the cost of the brick! On carbon, chrome, insulating, high alumina and other more expensive brick, "insurance" can be as little as 1/200 the brick cost!*

**REFRACTORY & INSULATION CORP.**

136 WALL STREET • NEW YORK 5, N.Y.

Sales Offices: Chicago, Ill.; Cleveland, Ohio; Bryn Mawr, Pa.; Newark, N. J.; Buffalo, N. Y.

*Manufacturers of* | Castable and Bonding Refractories; FURNACE BLOK; Blankets, Block, Plastic and Fill Insulations.


nounced the availability of a new, rotary spot printer for imprinting cut-to-length galvanized sheets and other flat products.

The unit enables galvanized sheet producers and manufacturers of other flat products to control the position and number of trade-marks or imprints desired per sheet. Also, it prints at top line speeds.

The electronically operated printer is mounted over the galvanized sheet conveyor line just before the piler and beyond the roller leveler. Since it is located in the cut-to-length area, it enables producers to trade-mark prime quality sheets only.

The location and number of imprints is governed by a unique electronic control system. And, because the printer is mechanically driven, only the printing die comes in contact with the sheet surface. The new unit eliminates the danger of surface marring or distortion on even the lightest gauge sheets.

The unit's ink system employs a pump to keep ink continuously circulating and free flowing. To minimize maintenance and attention, an automatic viscosity control system may be added.

The printer features push-button control which converts the unit to "spot" printing or continuous printing, as desired.

### TRANSFORMERS

△ Compact network transformers, designed to fit into close quarters, are offered in 300 through 2500 kva ratings by Wagner Electric Corp. Space-saving features of these transformers permit uprating existing secondary network systems by installing higher transformer ratings in present vaults, and also permits lower construction costs on new systems.

Transformer enclosures have corrugated walls to provide smooth radiating surfaces free from dirt-catching corners, permitting easier cleaning and painting when required. An anti-corrosive finish and a special asphalt base undercoating provide years of protection even under adverse conditions in underground vaults.

A compact liquid-filled high voltage rotary switch with matching cable termination compartment is welded to the enclosure. This switch was designed and developed by

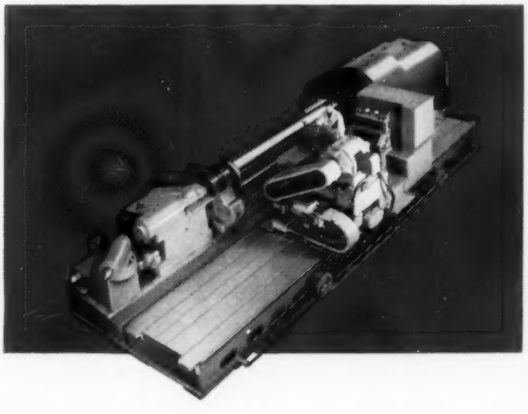
# This roll reflects the precision in Farrel's new fine-feed grinding design

The roll you see above was photographed at the Farrel plant during a recent test of a grinder on order. Ground to a finish of one micro inch . . . or smoother than glass . . . this roll effectively demonstrates the amazing accuracy of Farrel's new heavy-duty roll grinder.

This machine incorporates the most significant roll-grinding improvement in twenty years: the new trunnion-tilt, pivoted, infeed system. This unique design has a wheelhead which is tilted into the work by means of the same support and leverage system that makes Farrel crowning the most accurate obtainable. Since the system is free of backlash, it permits positive wheel movement in either direction. In previous designs, accuracy was limited by friction resulting from a sliding wheelhead.

For manual operation, the infeed handwheel is graduated to .0001". A control stop enables the operator to withdraw the wheel as desired, then infeed it to precisely its former position.

For further details, send for a copy of bulletin 53DM.



**FARREL-BIRMINGHAM COMPANY, INC.**
**ANSONIA, CONNECTICUT**

*Plants:* Ansonia and Derby, Conn., Buffalo and Rochester, N.Y.
*Sales Offices:* Ansonia, Buffalo, Akron, Chicago, Los Angeles, Houston, Atlanta
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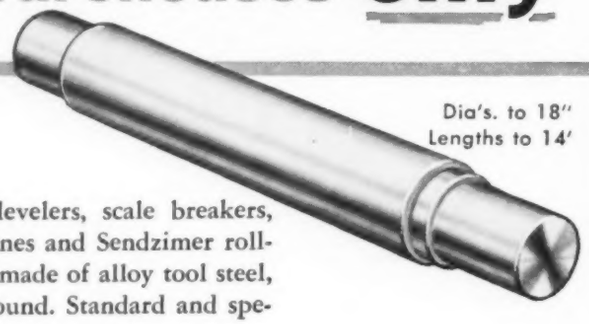
# For STEEL MILLS

## and warehouses *only*



**"HILL ACME" ROLLS**

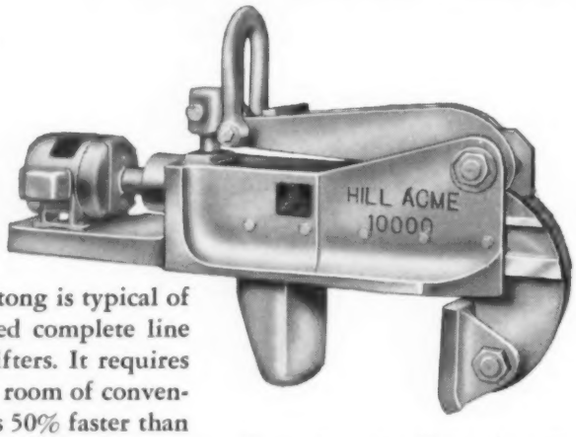
Dia's. to 18"
Lengths to 14'

Custom made for levelers, scale breakers, straightening machines and Sendzimer rolling mills. Precision made of alloy tool steel, heat treated and ground. Standard and special types.

**"CLEVELAND" METAL CUTTING KNIVES**

The product of forty years of experience in manufacturing alloy grade, metal cutting knives of all types for shearing hot and cold metals.

**"HILL ACME" MOTORIZED LIFTERS**




This vertical coil tong is typical of the newly designed complete line of HILL ACME lifters. It requires only 1/3 the head room of conventional tongs and is 50% faster than mechanical types. Gives a constant grip ratio regardless of wall thickness and can be prepositioned to eliminate damage to the coil. Available up to 80,000 lbs. capacity. Contact us for "C" hooks, Rack Lifters, Billet, Sheet, Plate, Bar, Ingot and Ingot Mould Lifters.

**THE HILL ACME COMPANY**

**1201 West 65th Street • Cleveland 2, Ohio**

MANUFACTURERS OF: "HILL" Grinding and Polishing Machines • "ACME" Forging Machines • "CANTON" Rotary and Alligator Shears • BAR-BILLET Shears MATERIAL HANDLING Equipment • "CLEVELAND" Knives and Shear Blades.


Wagner to meet the requirements of network systems.

Improvements in core and coil design of these network transformers result in excellent electrical performance. Cores are assembled using beveled and notched laminations sheared from cold-rolled oriented grain steel and individually annealed in a continuous roller hearth furnace to obtain extremely flat configuration. This design permits using yoke iron and core iron of the same width, with only a small lap joint at the beveled corners. Beveled corner joints materially reduce across-the-grain flux which results in low core loss, low exciting current and low sound level. Coils are wound on rectangular insulating members, the low voltage coils being of sheet copper to which the low voltage buses are brazed. This design provides great mechanical and short circuit strength and more even dissipation of heat, in a compact assembly of reduced dimensions.

Network transformers are available with standard high voltages of 2400/4160Y through 34,500 volts, and low voltages of 216Y/125 and 480Y/277 volts.

## FLEXIBLE COUPLINGS

△ Heavy-duty couplings heretofore available from Lovejoy Flexible Coupling Co. for applications up to 4250 hp can now be furnished with ratings up to 8500 hp. Intended for severe and continuous service, the new additions to the Type H line are easy to install, and incorporate individual load cushions which transfer the entire load, thus eliminating metal-to-metal contact at the jaws.

Driving and driven shaft connections are made quickly and easily, with simple and positive alinement procedure using only a straight edge. The couplings require little or no maintenance once they are placed in service and require *no lubrication*. On nonreversing loads, advancing or reversing load cushions provide double cushion life. Cushions can also be removed at any time without disturbing driving or driven units. In addition, all parts are plainly visible for quick spot inspection.

Type H flexible couplings are available with bore sizes ranging up to 9½ in. Bodies and jaws are completely machined electric steel

or nodular iron castings. Load cushions can be selected from a complete range of materials to assure maximum service life and economy under any operating conditions.

### MOTOR STARTER LINE

△ A new line of JIC NEMA 12 combination motor starters with QMQB fusible disconnects has been introduced by Federal Pacific Electric Co., featuring unique safety advantages as well as the most compact design known.

With a wide range of industrial applications in the automotive, chemical, steel, processing and OEM fields, the new JIC NEMA 12 combination motor starters are particularly adaptable for use in single motor machinery located where oil or nonexplosive dust is a problem.

So compact have these motor starters been designed, every unit in the line is smaller in some way than all other known devices of similar ratings. The smallest unit is only $8\frac{3}{16}$ in. wide, $6\frac{5}{16}$ in. deep, and $29\frac{5}{6}$ in. high, and is so engineered that it can easily be installed within the web of a 10-in. I-beam.

The unusual safety features of the new JIC NEMA 12 combination motor starter line stem from the QMQB fusible disconnects which are all equipped with integral rotary handles. These handles not only eliminate mechanical linkage, but offer the other safety advantages of positive on-off indication and the ability to use up to three padlocks on the door, open or closed.

The interlocking system of the new motor starters includes a heavy duty door handle interlocked with the door. Before the switch can be thrown on, the door must be fully closed and latched. Even with the switch off, a tool is required to open the door.

When the switch is on, a double interlock is in force, but if desired, this is defeatable in cases where a maintenance check is wanted with the power on. Otherwise, the switch cannot be thrown on with the door open unless two interlocks are defeated.

Despite the ultra safety built into the interlocking system of the new JIC NEMA 12 combination motor starters, their design has been made flexible so as to permit field modifications to eliminate certain inter-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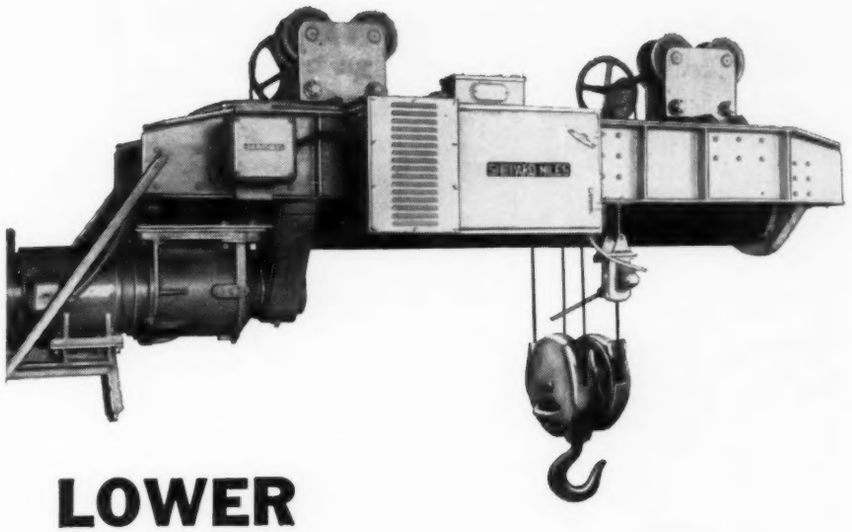

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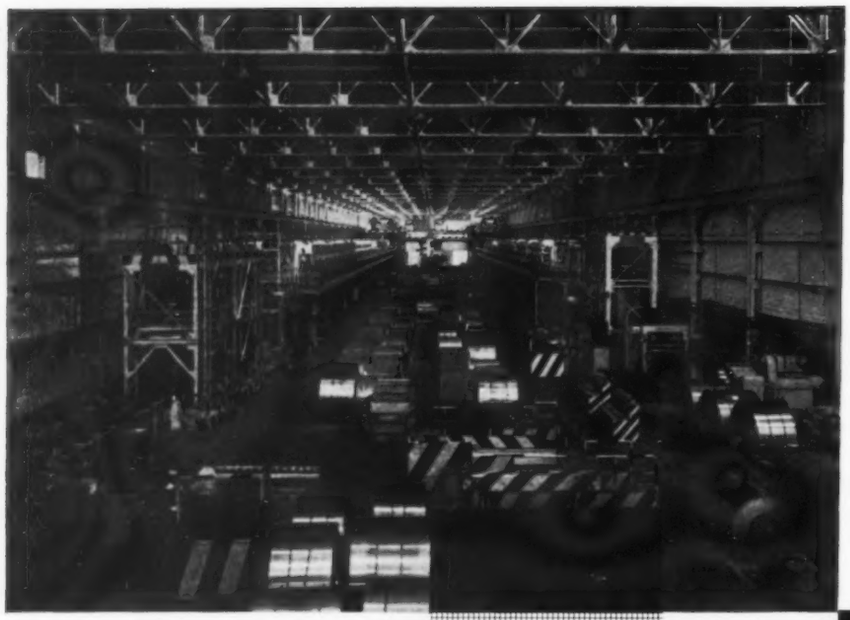
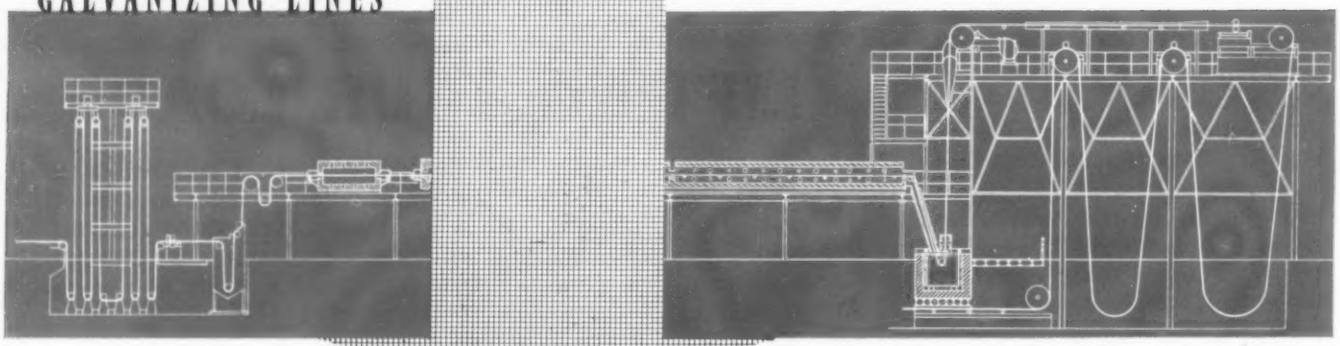


# FURNACES AND HEATING EQUIPMENT

General view of two galvanizing lines constructed for S.A. Phenix Works at Flemalle-Haute (Belgium).

## HEURTEY

## HEURTEY - SENDZIMIR CONTINUOUS WIDE STRIP GALVANIZING LINES



world references

PARIS - LIEGE - LYONS - MADRID - MILAN - VÄSTERÄS

HEURTEY constructed in FRANCE, BELGIUM and LUXEMBURG a large number of SENDZIMIR lines either as straight or as recuperative furnaces for a range of production of 3 - 10 t/h. Identical lines can also be designed for a production up to 20 t/h.

**HEURTEY**

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lock features. Thus, a voiding of defeating elements can be accomplished to provide almost any desired feature needed to fill particular requirements of plant safety.

Other features of the JIC NEMA 12 combination motor starter include: a line-side shield with "test probe" holes; a heavy neoprene door gasket which closes against a knife edge for positive seal; a formed oil resistant rubber gasket around the switch opening; positive grounding of the switch handle and an "O"-ring seal on all rotary handles.

The combination motor starters are available in a variety of units, with motor starters ranging from NEMA 0 to 3, fusible or nonfusible, reversing or nonreversing. If desired, units are also available with the QMQB integral handle (but not the safety interlocking) for use in a NEMA Type 1 general enclosure.

All units meet JIC and NEMA standards, and can be shipped immediately.

## AIR POWER CYLINDERS

△ A new line of economical general purpose air power cylinders, the Series "C," has been announced by Hannifin Co., a division of Parker-Hannifin Corp.

This new 200 psi maximum air cylinder is available in $1\frac{1}{4}$ in., $1\frac{3}{4}$ in., $2\frac{1}{2}$ in., $3\frac{5}{8}$ in., and $4\frac{1}{2}$ in. bore sizes with standard strokes to 20 in. Single and double rod end models are offered.

One compact design provides three basic mounting positions; side, cap end or head end. Four mounting attachments can be supplied if desired.

## *Book Reviews*

"**The Art of Persuasive Talking,**" by Lynn Surles and W. A. Stanbury, Jr., has been published recently by McGraw-Hill Book Co., 330 West 42nd St., New York 36, N. Y. The book contains 283 pages, $5\frac{1}{2}$ x $8\frac{1}{2}$ in., is clothbound, and sells for $4.95. This down-to-earth guide employs methods that are quick, simple and basic. Each discussion starts from some statement of fear, dismay or frustration so often felt by people who desperately want to improve their ability to talk effectively. In answering these


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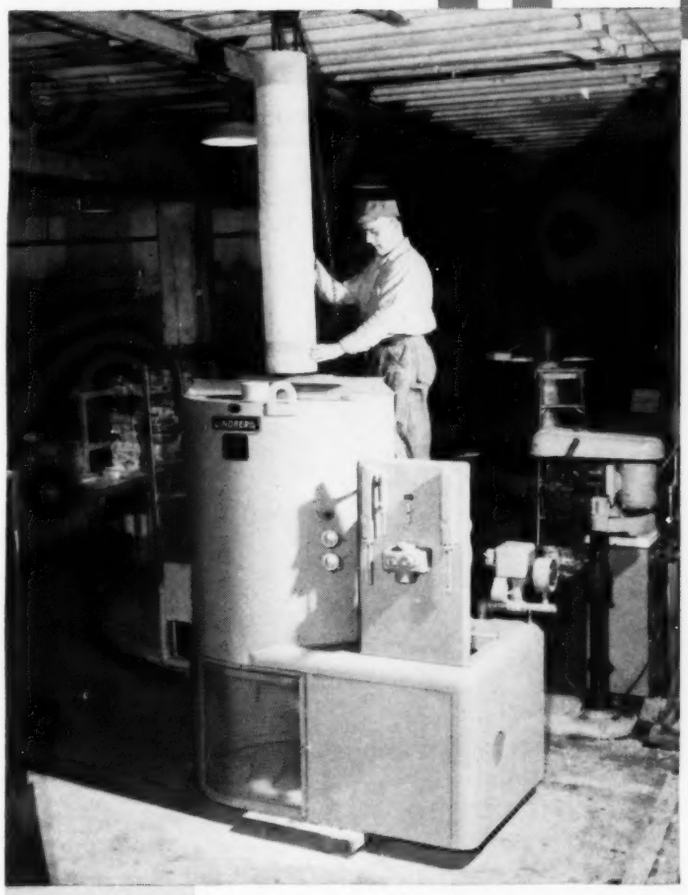

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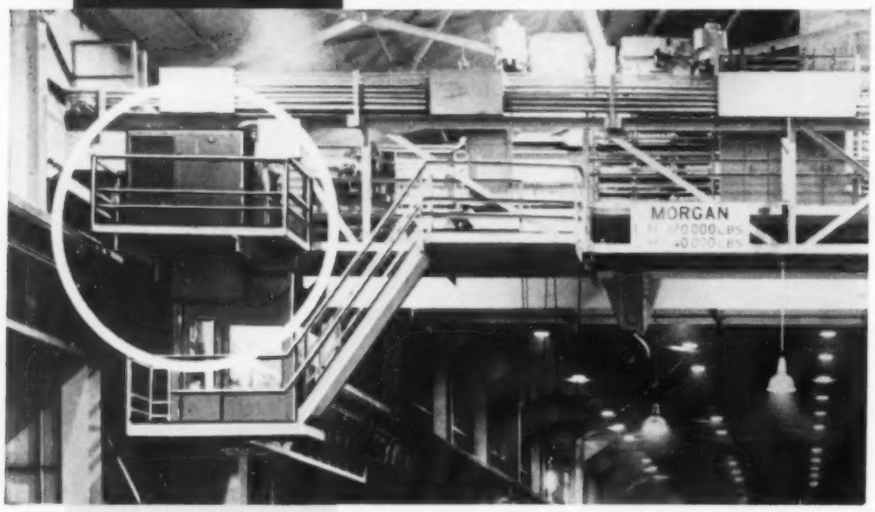
problems, the book makes specific suggestions on: how to turn disagreement into agreement without having arguments; how to get people to want to do the things you ask them to do; ways of preparing a talk when there is "no time to prepare"; how to use the power of suggestion in a sincere and natural way; how to propose and defend new policies; what you can do about weak grammar; why you need not worry about your voice . . . or physical handicaps; how to read aloud so papers and reports are high points of meetings. One entire section is devoted to showing how to handle 29 common talking situations including: giving an order, reprimanding, stopping gossip, telling a man he is promoted (or demoted), turning down an unqualified job applicant, handling a complaint, introducing a guest speaker and making an announcement.

**"Production of Wide Steel Strip,"** (Special Report 67) has been published recently by The Iron and Steel Institute, 4 Grosvenor Gardens, London, S. W. 1, England. The report contains 187 pages, 8½ x 11, and is clothbound. This is the report of a symposium held in London May 3–4–5, 1960, and contains the papers, together with the discussions, presented at this symposium. The 16 papers, presented at four sessions, cover future requirements of the tin plate and vehicle industries; steelmaking for wide strip; hot rolling of wide strip; cold rolling and heat treatment of wide strip; coatings on wide strip. There are many illustrations throughout the copy, using line drawings, graphs, actual photographs, tables, etc., to amplify the papers.

**"Guide to Design Criteria for Metal Compression Members,"** has been published recently by the Column Research Council, 319 West Engineering, University of Michigan, Ann Arbor, Mich. The book contains 112 pages, 8½ x 11, is leatherette bound, and is available from the Council at $5.00. This book presents a condensed summary of design criteria based upon recent as well as past research on metal compression members in buildings and bridges. The book is designed to explain special problems not covered by standard specifications, and to help in the preparation of specifications for such structures. It furnishes an understanding of behavior of compression elements and specification requirements whether the material is aluminum, steel or other metals. Areas of interest covered include centrally loaded columns, compression member details, laterally unsupported beams, and beam-columns. Construction metals under ASTM Specifications are covered, including the new ASTM A36 Structural Carbon Steel. Many illustrations are given, many references cited, tables and equations are included.

**"Guide to U. S. Government Statistics"** (third revised and enlarged edition), by John L. Andriot, has been published recently by Documents Index, Box 453, Arlington 10, Va. The book contains 402 pages, 8½ x 11-in., hard-cover bound, and sells for $15.00 (10 per cent discount for cash orders). The purpose of this reference is to

Model 527 AC-7.5 Lintern Aire-Rectifier installed on a Morgan crane operating in the annealing department of the tin mill plant at the Weirton Steel Division of the National Steel Corporation, Weirton, West Virginia. Note condenser on platform attached to footwalk. It is connected by refrigerant lines to the Cooling Unit in the cab, mounted on ceiling.

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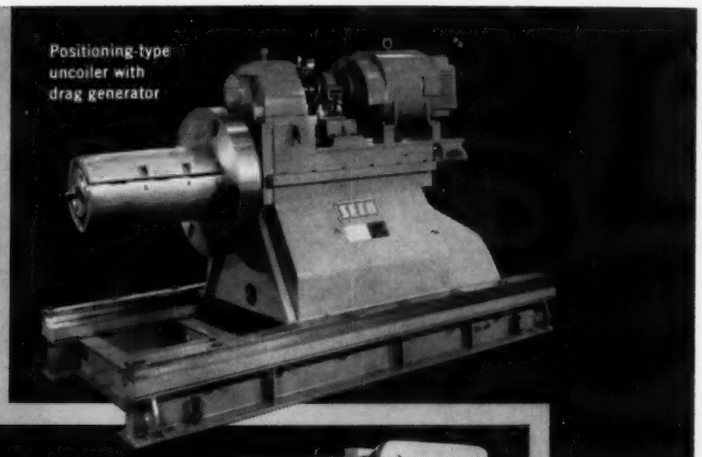
Positioning-type uncoiler with drag generator

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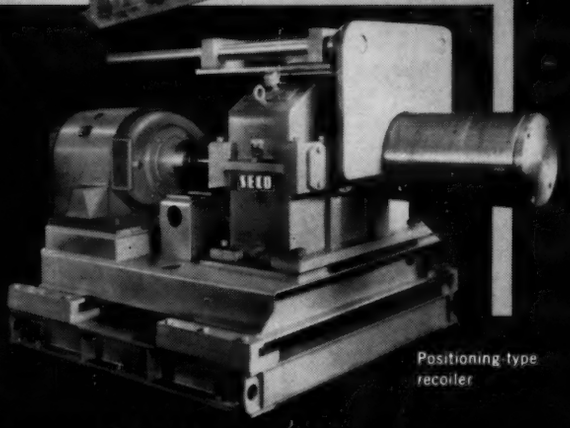
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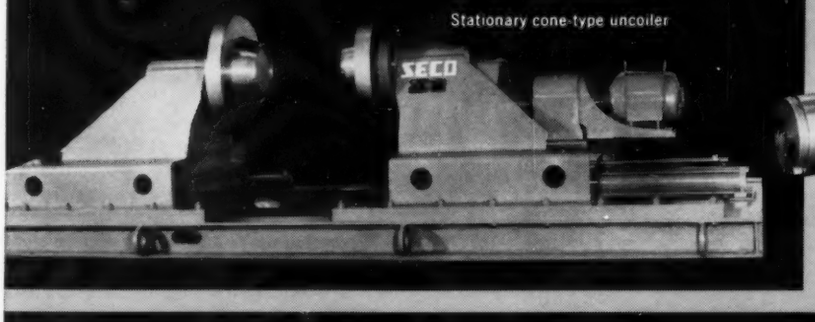
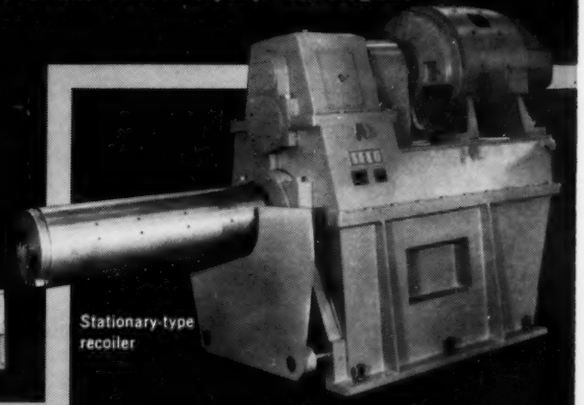

Stationary cone-type uncoiler


Stationary-type recoiler

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permit quick location of statistical sources by subject, and to provide a comprehensive guide to statistical contents of the voluminous output of Federal publications. The work consists of two parts: the guide, arranged by departments and agencies, listing the various publications containing statistical data with appropriate bibliographical information and concise, but comprehensive, annotations of the statistical contents and a detail subject index with each entry coded to show the frequency and type of data.

**"Dictionary of Mechanical Engineering,"** by Alfred Del Vecchio has been published recently by Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. The book contains 346 pages, 6 x 9 in., is clothbound, and sells for $6. This dictionary furnishes a sourcebook of prime definitions in the fields of architecture, automatic controls, engineering mechanics, fuels and combustion, power plants, and includes related definitions in the field of basic electricity, heat treatment of metals, basic mathematics and welding. Numerous illustrations are employed to further define terms, etc.

**"Semiconductor Abstracts, Vol. VI"** (1958 issue) has been compiled by Battelle Memorial Institute and has been published recently by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. This book contains 528 pages, 8 x 11 in., is clothbound, and sells for $14.00. This compilation was done under the patronage of The Electrochemical Society, Inc., and the Air Force Office of Scientific Research has contributed funds to the compilation. This volume contains abstracts of 1933 papers covering theory and application of the general field of semiconductors.

**"Zone Refining and Allied Techniques,"** by N. L. Parr has been published recently by St. Martin's Press, Inc., 175 Fifth Ave., New York 10, N. Y. The book contains 184 pages, 8½ x 5½ in., is clothbound, and sells for $8.50. This book relates practical information on recent advances in laboratory methods and equipment. The demand for extremely pure elements and compounds has resulted in the development of rapid zone-refining processing. The subject is presented here in a practical rather than a theoretical aspect to encourage wider application to fields of research and industry other than the development of transistors. Many references are cited, and numerous line drawings and photographs are employed to complete the text.

**"The Physical Examination of Metals"** (second edition), by B. Chalmers and A. G. Quarrell has been published recently by St. Martin Press, Inc., 175 Fifth Ave., New York 10, N. Y. The book contains 917 pages, 6 x 9 in., is clothbound, and sells for $30.00. This book gives an account of, in one volume, all the principal physical techniques for the examination of metals, apart from radiography. The chapters have been prepared by specialists—with chapters discussing various phases such as methods: optical, thermal, and radiation; measurements: electrical, elasticity using mechanical waves, coating thickness by magnetic methods; radioactive isotopes and their application in metallurgy; microradiography and autoradiography; modern vacuum techniques, etc. The book is amply illustrated, employing tables, line drawings, photographs, etc., to amplify and complete the text.

**"The Fermi Surface,"** edited by W. A. Harrison and M. B. Webb, has been published recently by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. The book contains 356 pages, 8½ x 11 in., is clothbound, and sells for $10.00. This book contains the proceedings of an international conference on Fermi surfaces held at Cooperstown, N. Y., August 22, 23, 24, 1960 sponsored by Air Force Office of Scientific Research and the General Electric Research Laboratory. The remarkable progress of the last few years in the understanding of the electronic properties of metals is summarized, the current status of the science is clarified, and the problems which still require solution are defined. Numerous tables, equations, graphs and photographs are used throughout the book. Both author index and subject index are given.


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if he has a bad sore throat, call your physician — especially if there is a high fever, swollen neck glands, difficulty in swallowing, nausea or vomiting.

**For medical advice,**
*see your doctor.*
**For more information,**
*ask your Heart Association.*
**For greater advances against heart disease,**

***GIVE to your***
**HEART FUND**

# INDEX TO ADVERTISERS

## APRIL, 1961


A

Air Reduction Sales Co. ..... 60, 61
Allen-Bradley Co. ..... 27, 28
Alliance Machine Co. ..... Cover 2
Allis-Chalmers Mfg. Co. ... G-35, G-36, G-37, G-38, G-39, G-40, G-41, G-42
Allis Co., Louis ..... 6
American Manganese Steel Div., American Brake Shoe Co. ..... 232
American Shear Knife Corp. ..... 196
American Waldrich Mfg. Corp. ..... 230
ASEA Electric, Inc. ..... 194
Atlas Car & Mfg. Co. ..... G-31
Automatic Transportation Co. ..... 200

B

Babcock & Wilcox Co., The ..... 171
Badall Co., Inc., The ..... G-46
Bailey Meter Co. ..... 16
Baldwin-Lima-Hamilton Corp. ..... 162
Bearings, Inc. ..... 195
B-I-F Industries, Inc. ..... 226
Birdsboro Corp. ..... 206
Blaw-Knox Co., Aetna-Standard Div. ..... 1
Foundry & Mill Machinery Div. ..... 164-A
Bliss Co., E. W. ..... 12
Bristol Co. ..... 42
Browning & Co., Inc., Victor R. ..... 23
Bussmann Manufacturing Div., McGraw-Edison Co. ..... 168, 169

C

Chain Belt Co. ..... 48
Chemical Construction Corp. ..... G-53
Chromium Corp. of America ..... G-26
Cities Service Oil Co. ..... 181
Clark Controller Co. ..... 49
Cleveland Crane and Engineering Co. ..... 10
Cleveland Tramrail Div., Cleveland Crane and Engineering Co. ..... 57
Coronado Steel Co. ..... 197
Correct Air Corp. ..... 219
Cunningham Co., M. E. ..... 44
Cutler-Hammer, Inc. ..... G-58, G-59

D

Dahlstrom Machine Works, Inc. ..... 170
Davy & United Engineering Co., Ltd. ..... 8
Diamond Electronics, Div. of Diamond Power Specialty Corp. ..... 224, 225
Dixie Bearings, Inc. ..... 195
Dodge Manufacturing Corp. ..... G-56
Dow Industrial Service ..... 39
Drever Co. ..... 166
Duraloy Co., The ..... 239

E

Eaton Manufacturing Co., Cleveland Worm & Gear Div. ..... G-66
Dynamatic Div. ..... 209
Farval Div. ..... Cover 3, G-65
Ederer Engineering Co. ..... 53
Eichleay Corp. ..... G-30
Electric Furnace Co., The ..... 17
Electric Machinery Mfg. Co. ..... 214
Electro-Alloys Div., American Brake Shoe Co. ..... 203
Elliott Co. ..... 14, 15
Elwell-Parker Electric Co. ..... 24

F

Falk Corp., The ..... 56
Farrel-Birmingham Co., Inc. ..... 235
Farrell-Cheek Steel Co. ..... 51
Feller Engineering Co. ..... 227
Femco, Inc. ..... 180
Firth, & John Brown Ltd., Thos. ..... 7
Fly Ash Arrestor Corp. ..... 231

G

Gas Atmospheres, Inc. ..... 184
General Electric Co. ..... 32, 33, 34
General Refractories Co. ..... 216, 217
General Steel Castings Corp., National Roll & Foundry Div. ..... G-43
GPE Controls, Inc. ..... G-48
Great Lakes Carbon Corp. ..... 52
Green Fire Brick Co., A. P. ..... G-24

H

Hagan Chemicals & Controls, Inc. ..... 164-B, 165
Hallden Machine Co., The ..... G-64
Harbison-Walker Refractories Co. ..... Cover 4
Hazen Engineering Co. ..... 178, 179
Heppenstall Co. ..... G-61
Heurtey, S. A. ..... 238
Hill Acme Co., The ..... 236
Homestead Valve Mfg. Co. ..... 13
Hunt Valve Co. ..... G-34
Hyde Park Foundry and Machine Co. ..... G-50
Hydromation Filter Co. ..... G-60

J

Johns-Manville Corp. ..... 18, 19, 167

K

Kaiser Engineers ..... 20
Koppers Co., Inc. ..... 9, G-20, G-21, 161, 226, 242

L

Larco, Inc. ..... 240
Leeds & Northrup Co. ..... 160
Link-Belt Co. ..... 66, 176

M

Mackintosh-Hemphill Div., E. W. Bliss Co. ..... G-62, G-63
Magnaflux Corp. ..... 175
Manning, Maxwell & Moore, Inc. ..... 35
McKee & Co., Arthur G. ..... G-54
Mesta Machine Co. ..... Cover 1, G-29
Metal Blast, Inc. ..... 172
Midvale-Heppenstall Co. ..... 63
Minneapolis-Honeywell Regulator Co. ..... 36, 37, 212
Morgan Construction Co. ..... 190, 191
Morgan Engineering Co., The ..... G-33
Murray Manufacturing Co., D. J. ..... 62

N

National Electric Coil Div., McGraw-Edison Co. ..... 21
National Malleable & Steel Castings Co. ..... 210
North American Manufacturing Co. ..... 223
Northeast Ohio Machine Builders, Inc. ..... 213

O

Ohio Steel Foundry Co., The ..... 182

P

Pennsylvania Engineering Corp. ..... 177
Plibrico Co. ..... 31
Pollock Co., William B. ..... G-25
Poole Foundry and Machine Co. ..... 246
Porter, Inc., H. K. ..... 51
Post-Glover Electric Co., The ..... 45
Production Machinery Corp. ..... 186

R

Ramtite Co., The ..... 55
Refractory & Insulation Corp. ..... 234
Reliance Electric & Engineering Co. ..... 204, 205
Republic Flow Meters Co. ..... 189
Ringsdorff Carbon Corp. ..... 213
Rust Furnace Co., The ..... 159
Rust-Oleum Corp. ..... 46, 47

S

Salem-Brosius, Inc. ..... 233
Selas Corp. of America ..... 58, 59
Shepard Niles Crane & Hoist Corp. ..... 237
SIEMAG Siegener Maschinenbau GMBH ..... 5
Signode Steel Strapping Co. ..... G-55
Spectrochemical Laboratories, Inc. ..... 170
Spraying Systems Co. ..... 44
Square D Co. ..... G-27, 228, 229
Stamco, Inc. ..... 40
Steel Equipment Co. ..... 241
Sticker Industrial Supply Corp. ..... 43
Sutton Engineering Co. ..... G-32
Swindell-Dressler Corp. ..... 192, 193
Syntron Co. ..... 218

T

Taylor Chain Co., S. G. ..... 222
Taylor Instrument Cos. ..... G-52
Taylor Sons Co., Chas., The ..... 4
Timken Roller Bearing Co., The ..... 41
Tool Steel Gear & Pinion Co., The ..... G-44, G-45
Torrington Co., The ..... 64
Trabon Engineering Corp. ..... 220
Treadwell Co., M. H. ..... G-57

U

United Engineering & Foundry Co. ..... G-22, G-23
United States Steel Corp. ..... 188, 198, 199

V

Vaughn Machinery Co., The ..... 185

W

Wagner Electric Corp. ..... G-28
Wall Colmonoy Corp. ..... 62
Walsh Refractories Corp. ..... G-49
Wean Engineering Co., Inc., The ..... G-47
Wellman Smith Owen Engineering Corp. Ltd. ..... 50
Western Gear Corp. ..... 215
Wheelabrator Corp. ..... 22
Whiting Corp. ..... 187
Wichita Clutch Co. ..... 2
Wilson Engineering Co., Inc., Lee ..... G-51

Y

Youngstown Alloy Casting Corp. ..... 54
Yuba Consolidated Industries, Inc. ..... 38

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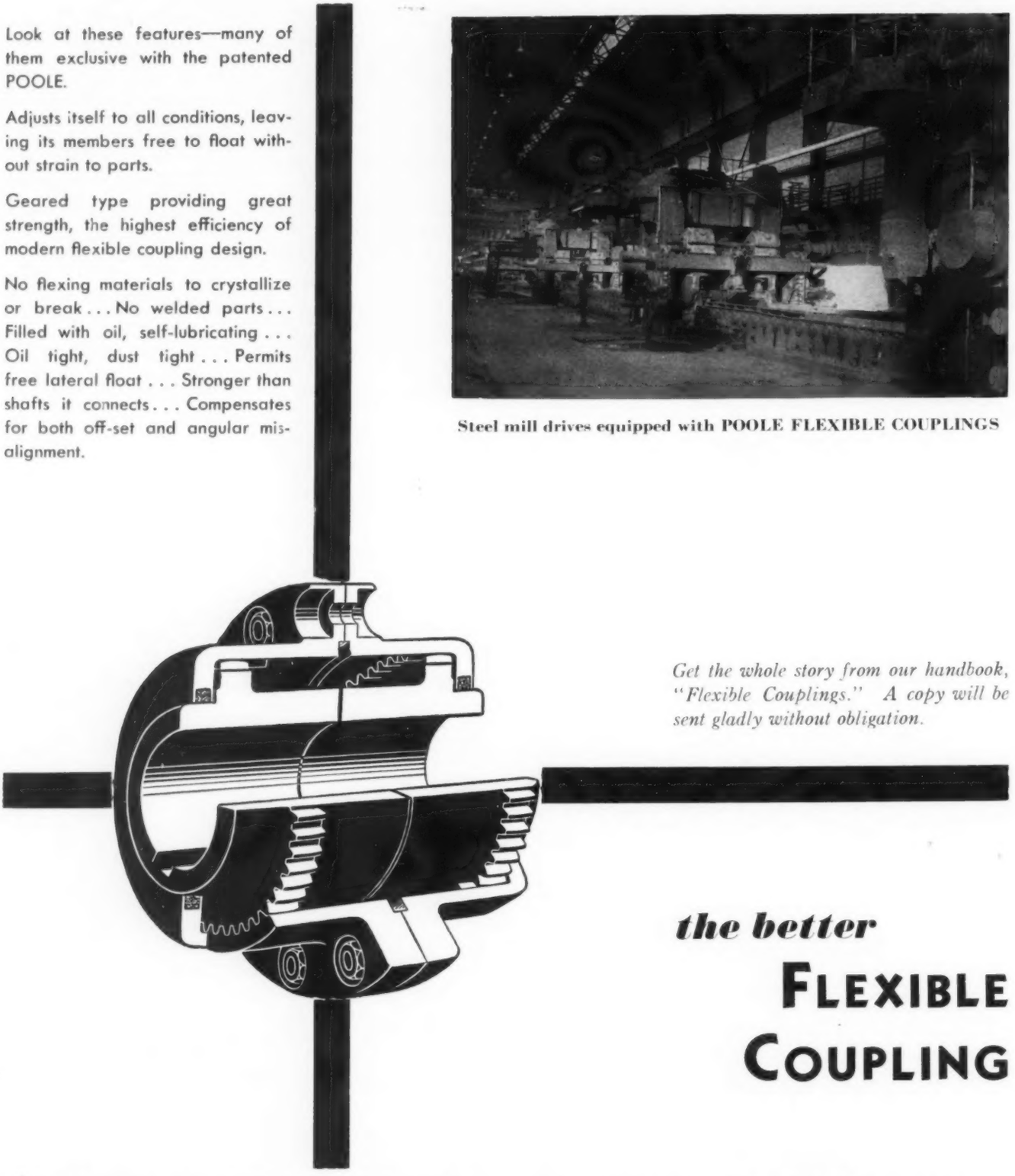

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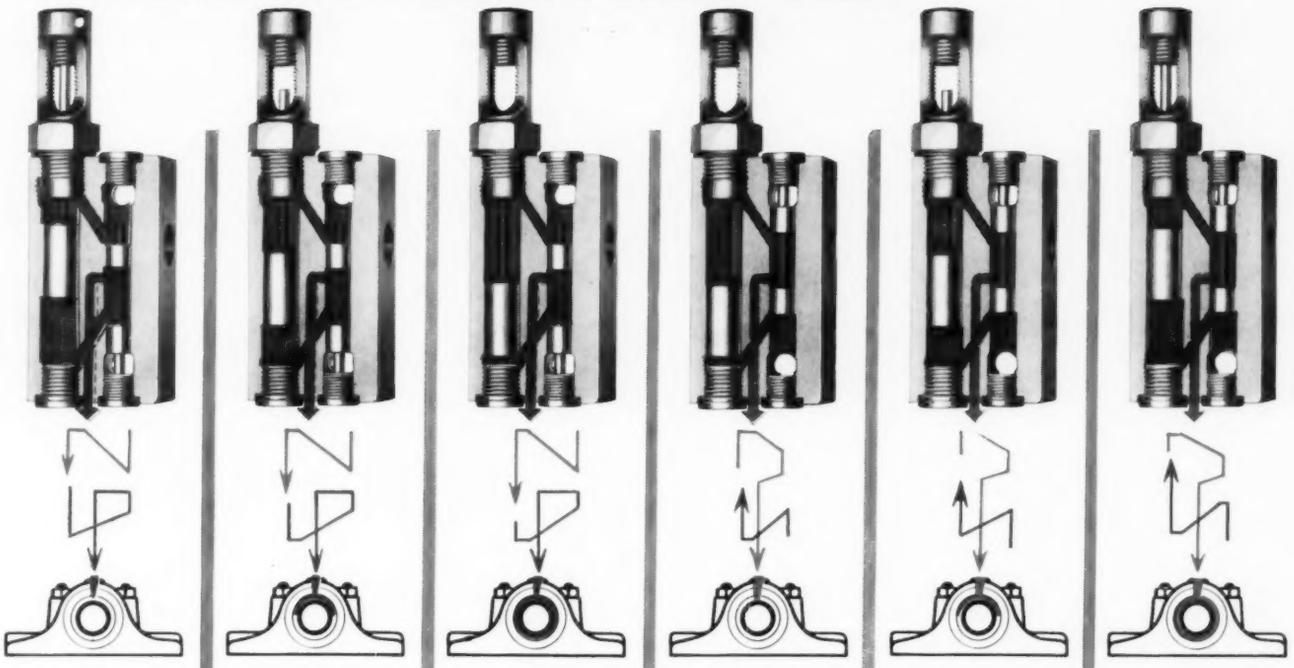

**1**

(In red) Lubricant under hydraulic pressure enters inlet at top right — pushing slide valve down and filling upper diagonal passage and chamber above main piston.

(In blue) By this movement, lower head of piston slide valve uncovers lower diagonal passage leading from the main piston chamber. This chamber is full of lubricant from the previous operation.

**2**

(In red) Lubricant under pressure entering through upper inlet port and into main chamber continues to force main piston downward —

(In blue) discharging lubricant through lower diagonal passage to vertical passage and to outlet port leading to bearing.

**3**

(In red) Lubricant entering from upper port has now forced the main piston to end of its stroke, and thus the full measured charge below piston has been delivered to the bearing.

Note that indicator stem has also moved down, indicating main piston has reached end of its stroke, and that no more lubricant will be delivered from this operation.

**4**

(In blue) Lubricant under hydraulic pressure enters inlet at bottom right — pushing slide valve up and filling lower diagonal passage and chamber below main piston.

(In red) By this movement, upper head of piston slide valve uncovers upper diagonal passage leading from the main piston chamber. This chamber is full of lubricant from the previous operation.

**5**

(In blue) Lubricant under pressure entering through lower inlet port and into main chamber continues to force main piston upward —

(In red) discharging lubricant through upper diagonal passage to vertical passage and to outlet port leading to the bearing.

**6**

(In blue) Lubricant continuing to enter under pressure from the lower port has now forced main piston to the end of its stroke, and thus the full measured charge above piston has been delivered to the bearing.

Indicator has reached its top limit, showing the job is done.

# That's why *FARVAL DUALINE* is today's most dependable, positive system of centralized lubrication

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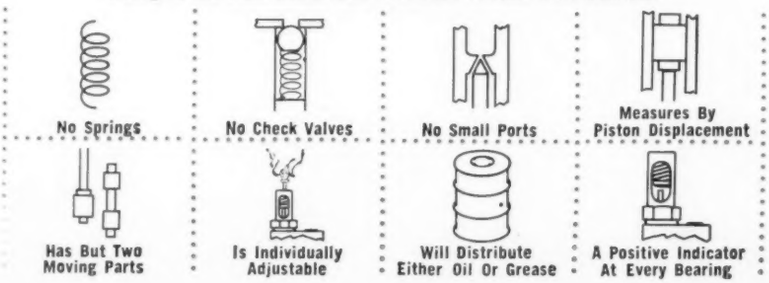
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No Check Valves
No Small Ports
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Has But Two Moving Parts
Is Individually Adjustable
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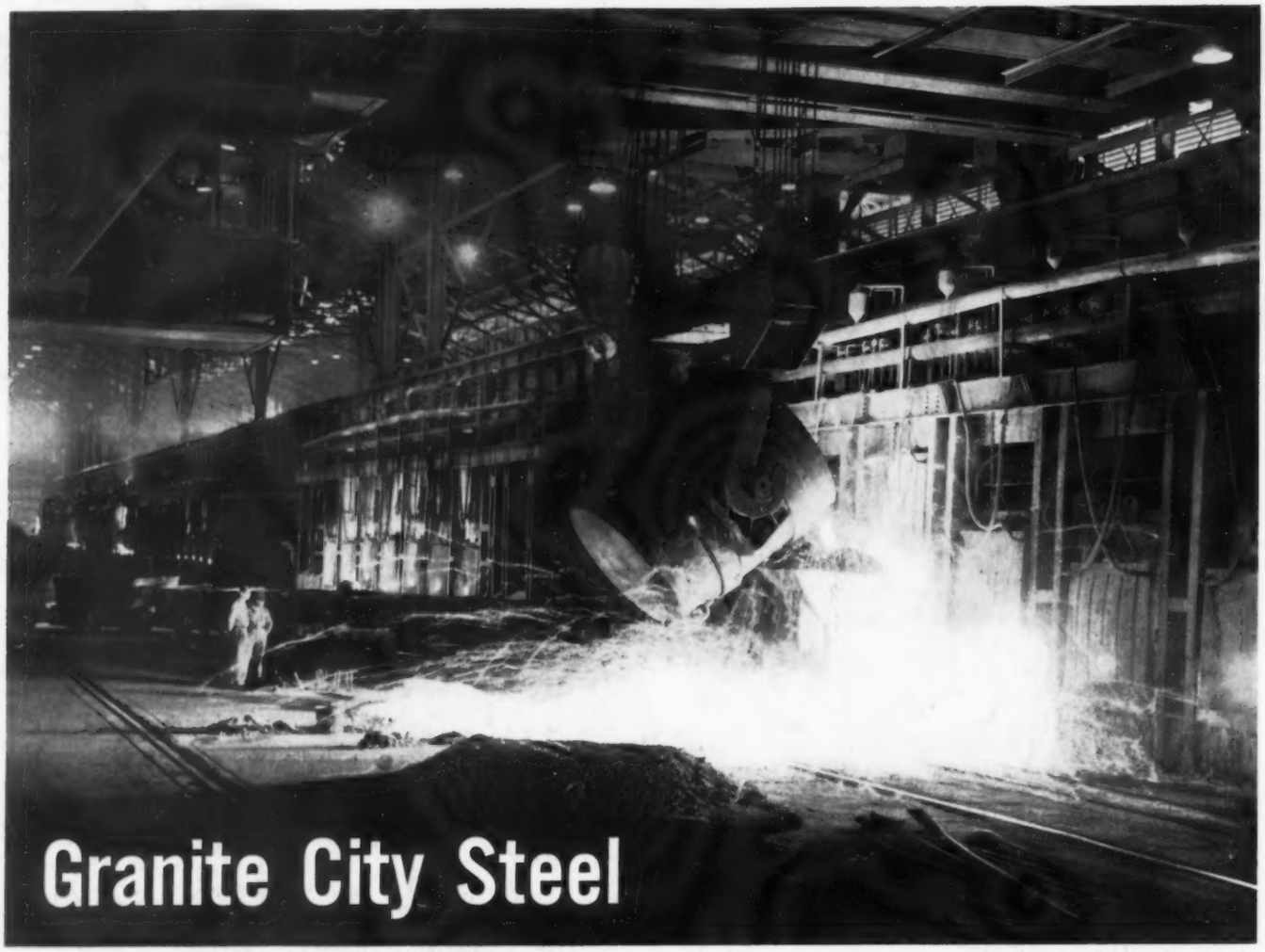


Enlarged open hearth furnaces were built with basic roofs.

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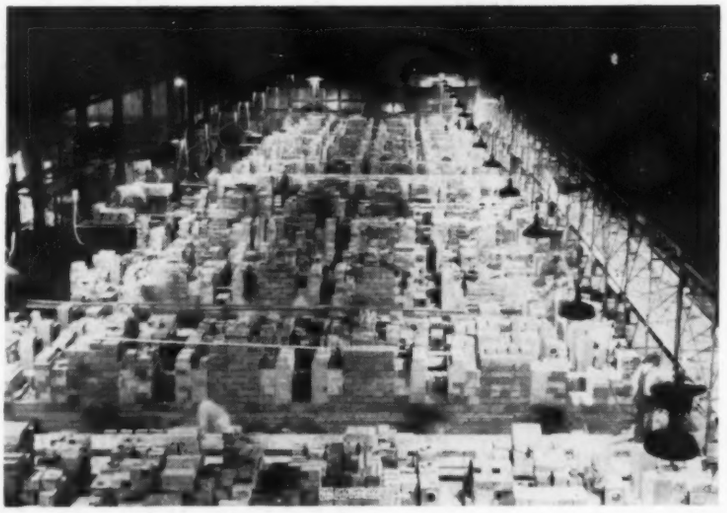
Harbison-Walker has maintained its leadership in the refractories industry through continuous research, product development, modernization and expansion of production facilities and an exceedingly effective quality control program.



Harbison-Walker refractories are being used in the new "C" battery of 61 coke ovens under construction, on the right, as well as in the present "A" and "B" batteries.

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